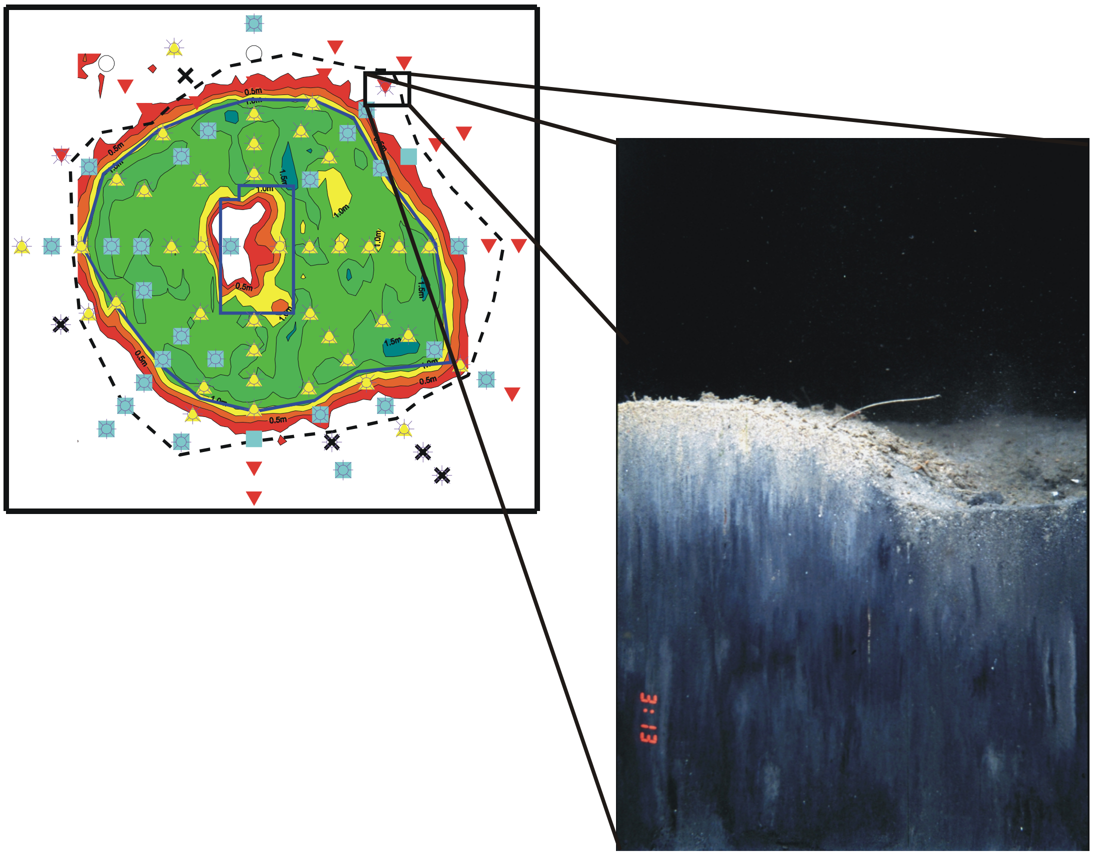
THE 1997 CATEGORY II CAPPING PROJECT AT THE NEW YORK MUD DUMP SITE: RESULTS FROM THE ONE-YEAR POSTCAP BATHYMETRY AND REMOTS® SURVEYS OF APRIL 1999



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ACKNOWLEDGMENT

This report presents results of the one-year postcap bathymetry and REMOTS® surveys for the 1997 Category II Capping Project at the New York Mud Dump Site. The surveys were conducted by Science Applications International Corporation (SAIC) of Newport, RI, under contract to U.S. Army Corps of Engineers - New York District (NYD). Dr. Stephen Knowles is the NYD manager of technical activities; Dr. Scott McDowell is SAIC's program manager.

Logistical and planning support for the survey was provided by Dr. Stephen Knowles and Mr. Monte Greges of NYD with assistance from Mr. Tim LaFontaine.

Ms. Kate Pickle, Ms. Melissa Swanson, and Mr. Ed DeAngelo of SAIC were responsible for mobilizing the field equipment and conducting the bathymetric survey operations. Ms. Kate Pickle, Ms. Melissa Swanson, and Mr. Ray Valente were responsible for mobilizing the field equipment and conducting the REMOTS® survey operations. Both surveys were conducted aboard the NYD's 85-ft. harbor tug, M/V *Gelberman.* The crew of the M/V *Gelberman* is commended for their skill in vessel handling and their dedication during long hours of operations at the former Mud Dump Site.

Mr. Jason Infantino processed the bathymetric data, produced the graphic data products, and prepared the bathymetry portion of this report. Ms. Melissa Swanson performed full image analysis on the REMOTS® images, produced the graphic data products, and prepared the REMOTS® portion of the report. Mr. Valente provided technical review of the report, while Mr. Tom Fox was responsible for report production.

1.0 INTRODUCTION

1.1 Background

Sediments dredged from the Port of New York and New Jersey historically have been placed in an ocean disposal site in the New York Bight known as the Mud Dump Site (MDS), located 6 nmi off the coast of Sandy Hook, NJ. In response to growing concerns about site capacity and the environmental effects of dredged material disposal, a decision was made in 1996 to close the Mud Dump Site by September 1, 1997. On August 26, 1997, the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers finalized the rule providing for closure of the MDS. Simultaneously, the site and surrounding areas that have been used historically for disposal of contaminated material were redesignated as the Historic Area Remediation Site (HARS). The locations of the former MDS and the HARS are shown in Figure 1-1.

The planned closure of the MDS on September 1, 1997 left the Port Authority of New York and New Jersey (PANY/NJ) with a limited period of time to dispose a finite volume of contaminated (i.e., Category II) dredged sediments at the site and cover these sediments with a layer of clean (i.e., Category I) sediment. A plan was developed in early 1997 to address dredging, ocean disposal and subsequent capping of the Category II material at the MDS prior to the September 1 closure. This capping project is referred to as the 1997 Category II Capping Project.

The Category II project material was dredged from selected berthing facilities at Port Newark and Port Elizabeth, New Jersey. Placement of this material within the southeast quadrant of the MDS (Figure 1-2) began in late May 1997 and continued until August 10, 1997. During this period, roughly 700,000 yd^3 of material were placed, creating a distinct mound on the bottom. Immediately following the completion of the placement operation, capping of the project material with 2.4 million cubic yards of clean sand began on August 21, 1997. The capping operation continued intermittently until January 18, 1998, when it was demonstrated that a 1-m thick layer had been placed over the entire project material footprint.

As part of the project, the NYD contracted SAIC to collect data on seafloor characteristics in the area of the MDS selected for placement of the Category II material. Data were collected prior to placement of the dredged material, as well as during and immediately following both the disposal and capping operations. In particular, high-resolution bathymetric data and REMOTS® sediment-profile imaging data were collected in March and April 1998, immediately following the completion of the capping operation (Figure 1-3). The data provided information about the thickness and distribution of the sand cap and also were used to assess the impacts of the capping project on benthic habitat quality and recolonization by benthic organisms.

This report presents results of bathymetric and REMOTS® surveys conducted on March 31-April 1 and April 27–29, 1999, respectively. These two surveys were conducted a little over a year following the completion of the capping operation and roughly one year following the previous postcap surveys (Figure 1-3). The objectives of these two one-year postcap surveys were: 1) to detect any changes in the topography of the capped project mound that might indicate a loss of sand cap material, and 2) to assess overall benthic habitat quality and recolonization of the sand cap.

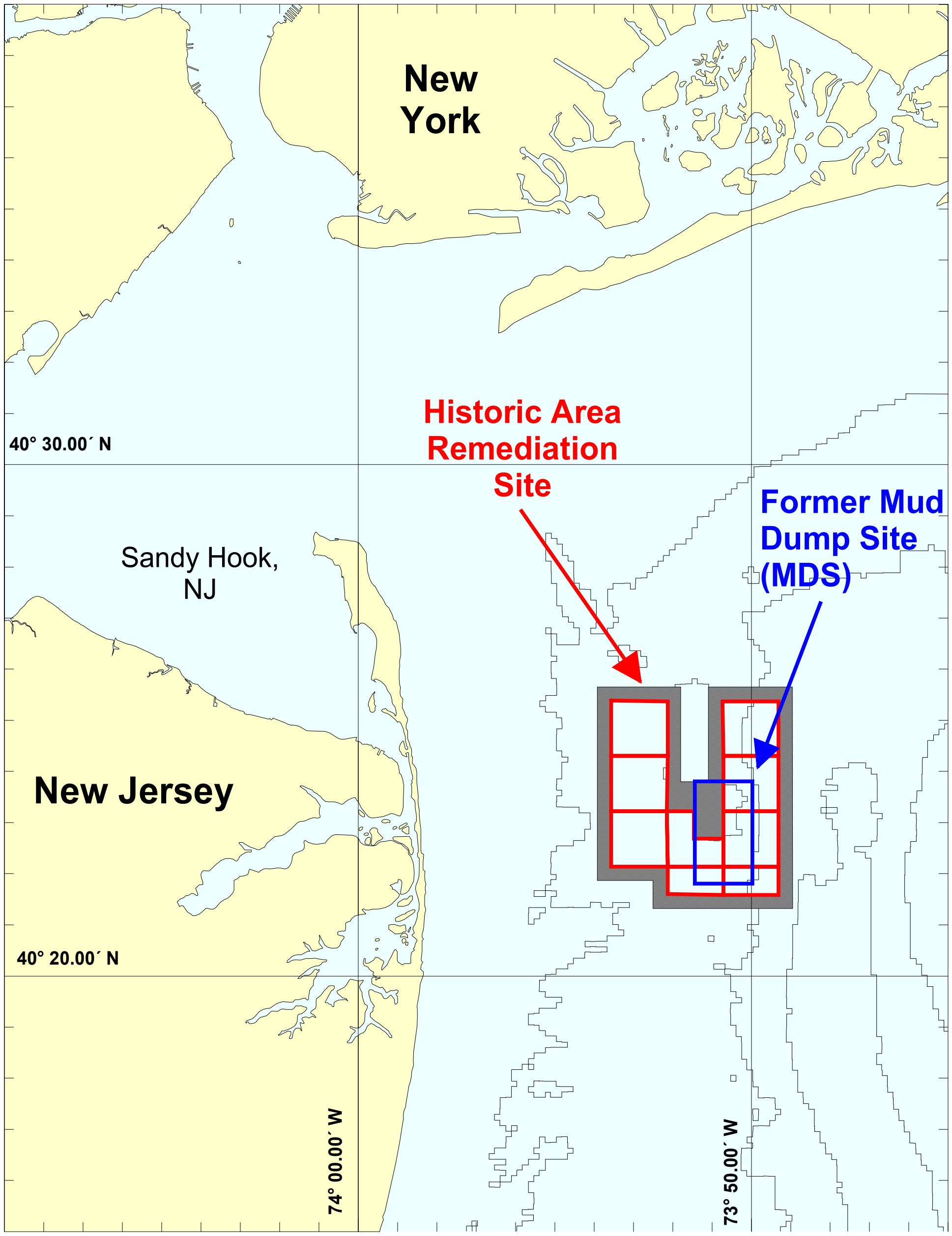


Figure 1-1. Map showing the locations of the former Mud Dump Site and the Historic Area Remediation Site in the New York Bight.

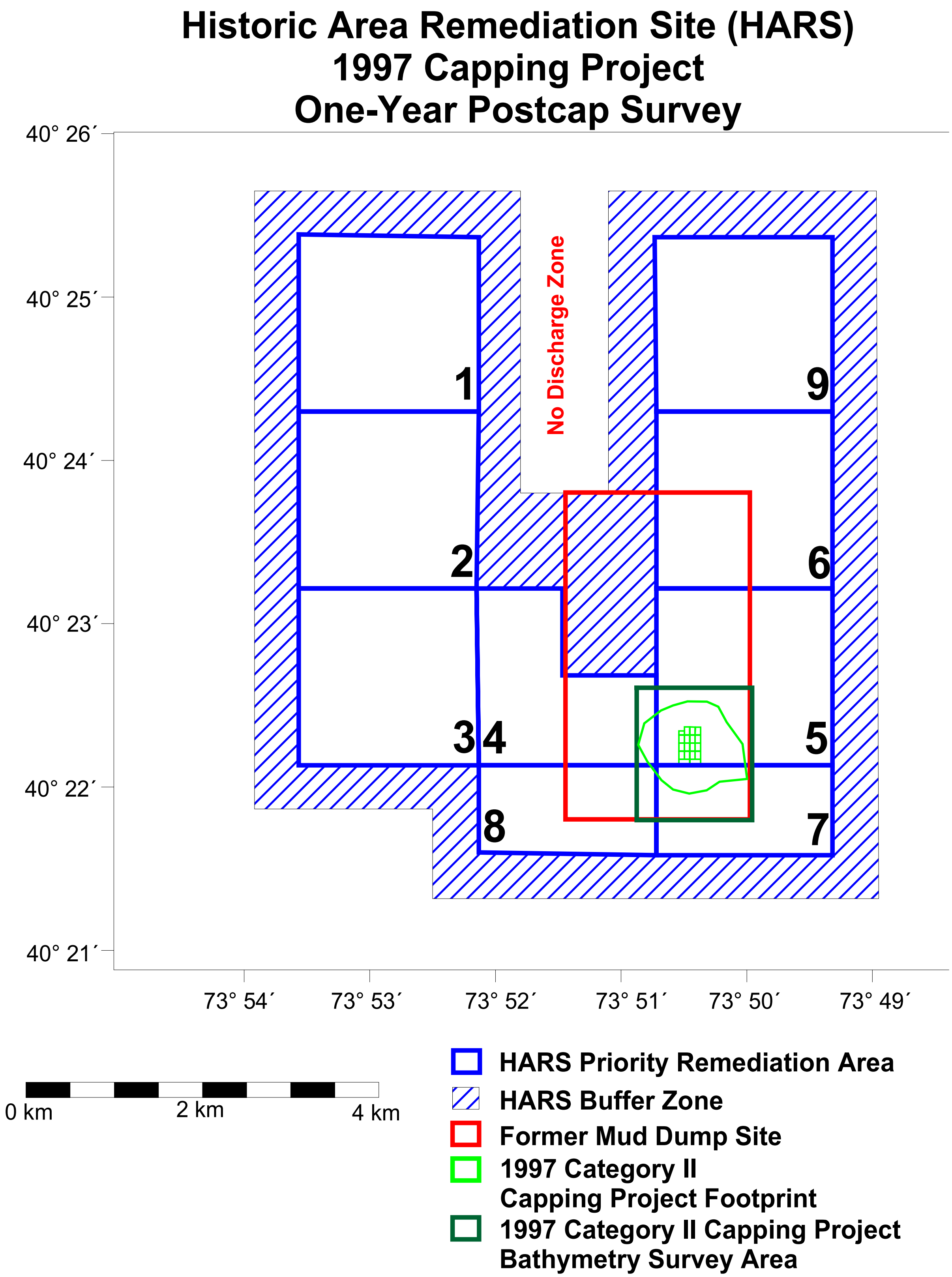


Figure 1-2. Map showing the HARS, the former MDS, and the footprint of the 1997 Category II Capping Project within the southeast quadrant of the former MDS.

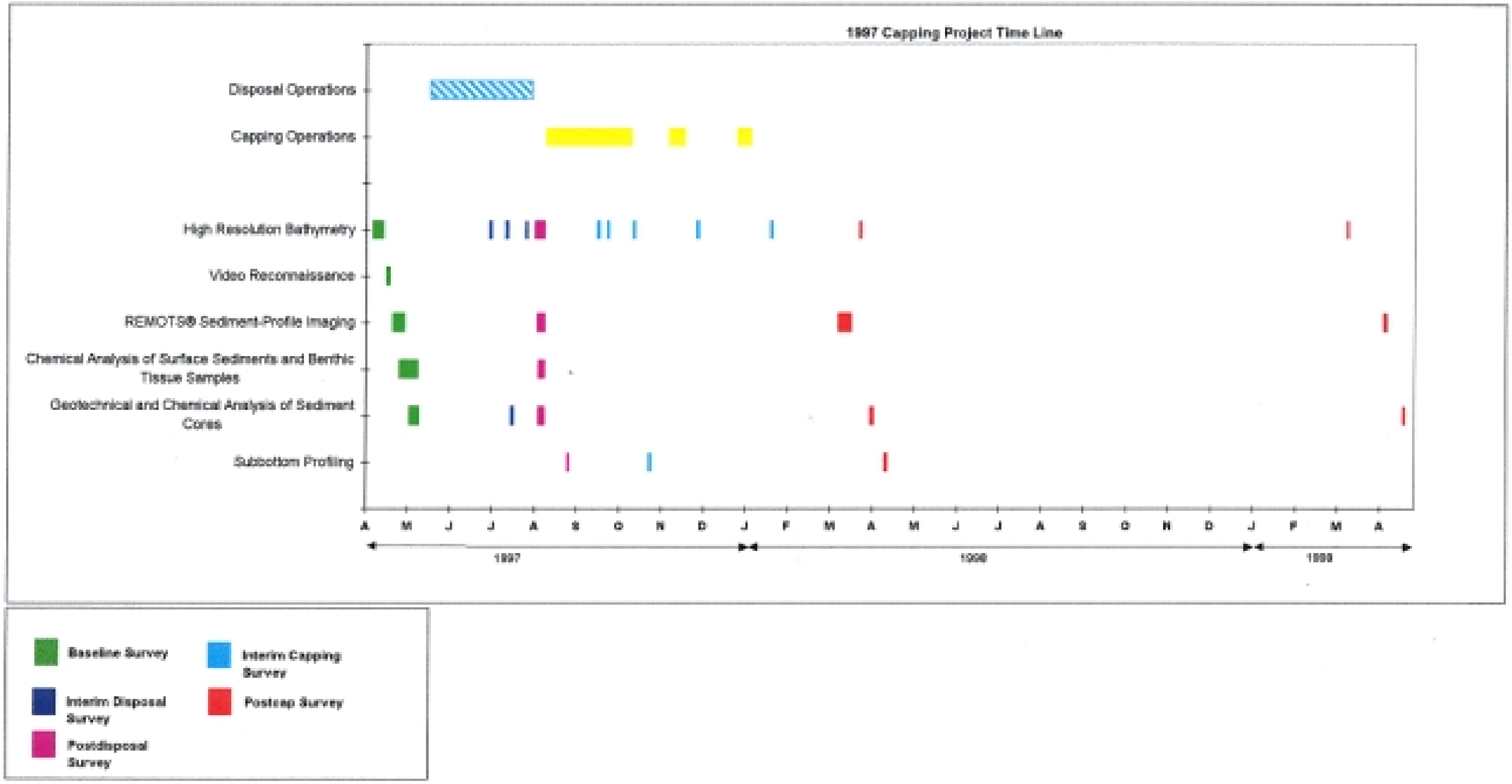


Figure 1-3. 1997 Category II Capping Project time line.

2.0 METHODS

2.1 Navigation

The 1999 one-year postcap bathymetric and REMOTS® surveys were conducted aboard the NYD's 85-ft harbor tug, M/V *Gelberman*. SAIC installed its Portable Integrated Navigation and Survey System (PINSS) on the vessel to provide navigational support for the crew and to digitally store survey data. Vessel positioning along predetermined survey lines (bathymetry) and at predetermined stations (REMOTS®) was accomplished using Trimble GPS positioning system interfaced with the PINSS. The PINSS utilized a Toshiba 3200DX personal computer to provide real-time navigation, as well as to collect position, depth, and time data for subsequent analyses. One to five meter accuracy was achieved by applying a differential correction to the GPS signals from a signal acquired from the U.S. Coast Guard broadcast station located at Sandy Hook, NJ. Vessel position was displayed on two monitors, one for the survey navigator and the second for the helmsman to aid in steering the vessel toward target station locations. Each fix incorporated time of day, the vessel's position in Latitude and Longitude and UTM coordinates, signal quality, station and replicate identification, and selected data from environmental sensors such as the depth sounder.

All differential GPS navigation data were received, logged and displayed in the North American Datum 1983 (NAD 83) geographic coordinate system. While SAIC Standard Operating Procedures have previously involved applying a correction for an offset to NAD 27 prior to submission of coordinate data to the NYD, the coordinate data in this report are presented in NAD 1983 to conform with side-scan sonar, sediment grab sampling, and other data collected by SAIC.

2.2 Bathymetric Survey Operations

Bathymetric operations were conducted during the period of March 31–April 1, 1999. The survey area measured 1500 m (north-south) by 1300 m (east-west), identical to that of the previous postcap survey performed in April 1998 immediately following the completion of capping operations. The center of the survey region corresponded with the target location for the disposal mound of the 1997 Category II capping project. Depth soundings were collected with an Odom DF3200 Echotrac® survey echosounder using a 208 kHz transducer with a 3° beam angle. The Odom simultaneously displayed water depth data on a chart recorder and transferred digital sounding data to the PINSS. The echosounder collected 6-8 soundings per second and transmitted an average value to the PINSS at a rate of one sounding per second. Measurements acquired by a Seabird Electronics, Inc., Model SBE-19-01 conductivity-temperature-depth (CTD) profiler were used to calculate vertical profiles of sound velocity in the water column at the beginning and end of the survey day.

Water level data from the Sandy Hook, NJ, tide station were obtained from the NOAA Ocean and Lakes Levels Division (OLLD) web-server via the World Wide Web (WWW). The NOAA station provides water level readings at 6-minute intervals referenced to Mean Lower Low Water (MLLW). Following the survey, the water level data from Sandy Hook were applied to the bathymetric data from the survey region to remove water level variations due to tides. Because the tide at Sandy Hook is 45 minutes later than the tide at the Mud Dump Site (NYD – Survey Branch), a time adjustment was applied during the data processing.

Depth soundings were collected along 52 north-south oriented survey lines spaced 25 m apart within the 1500 m by 1300 m survey area. To reduce any horizontal positioning artifacts when comparing one-year postcap data to previous surveys, this survey plan is identical to multiple disposal and cap monitoring bathymetric surveys conducted by SAIC since April 1997.

2.3 Bathymetric Data Processing

Using SAIC's Hydrographic Data Analysis System (HDAS), bathymetric soundings were edited for outliers and corrected for sound velocity, transducer draft, and tidal variation. Following the application of all correctors, the depth soundings were spatially averaged to produce a bathymetric grid of cells each having dimensions of 25 m by 25 m. The gridded bathymetric data were used to produce the various topographic maps included in this report, and will be incorporated into the GIS database of the Disposal Analysis Network for the New York District (DAN-NY) which resides at the New York District (SAIC 1997a). Additionally, the bathymetric grid from this survey was compared with: 1) the August 19, 1997, postdisposal bathymetric survey grid, to identify the total amount of material if any that may have accumulated or shifted from the beginning of capping operations, and 2) the April 8, 1998, postcap bathymetric survey, conducted for the PANY/NJ, roughly two months following the completion of the capping operations, to identify any changes in the cap topography that may have occurred during the past year.

2.4 REMOTS® Survey Operations

2.4.1 Field Sampling Design

The rectangular area within the southeast quadrant of the MDS selected for placement of the 1997 Category II project material is called the 1997 Base Mound Area (Figure 2-1). This area is located slightly to the east of the area used for the 1993 Dioxin Capping Monitoring Project (Figure 2-1). A REMOTS® survey conducted in August 1997, immediately following the completion of the dredged material placement phase of the 1997 Category II Project, was used to delineate the footprint of the project material mound. It was found that the 1997 dredged material footprint encompassed a roughly circular area surrounding the Base Mound Area, as expected based on predisposal modeling, and some of the 1997 project material overlaid the 1993 Dioxin Capping Monitoring Project sand cap (Figure 2-1). The sand capping operations which began in August 1997 occurred within the polygon delineating the dredged material footprint. A series of bathymetric and subbottom profiling surveys conducted during and immediately following the capping phase were used to confirm that a sand layer measuring at least one meter in thickness was placed over the entire dredged material footprint. A one-year postcap bathymetry survey (results of which are included within this report) was conducted detect any changes in the topography and thickness of the sand cap.

1997 Category II Capping Project
One-Year Postcap REMOTS® Survey
Station Locations

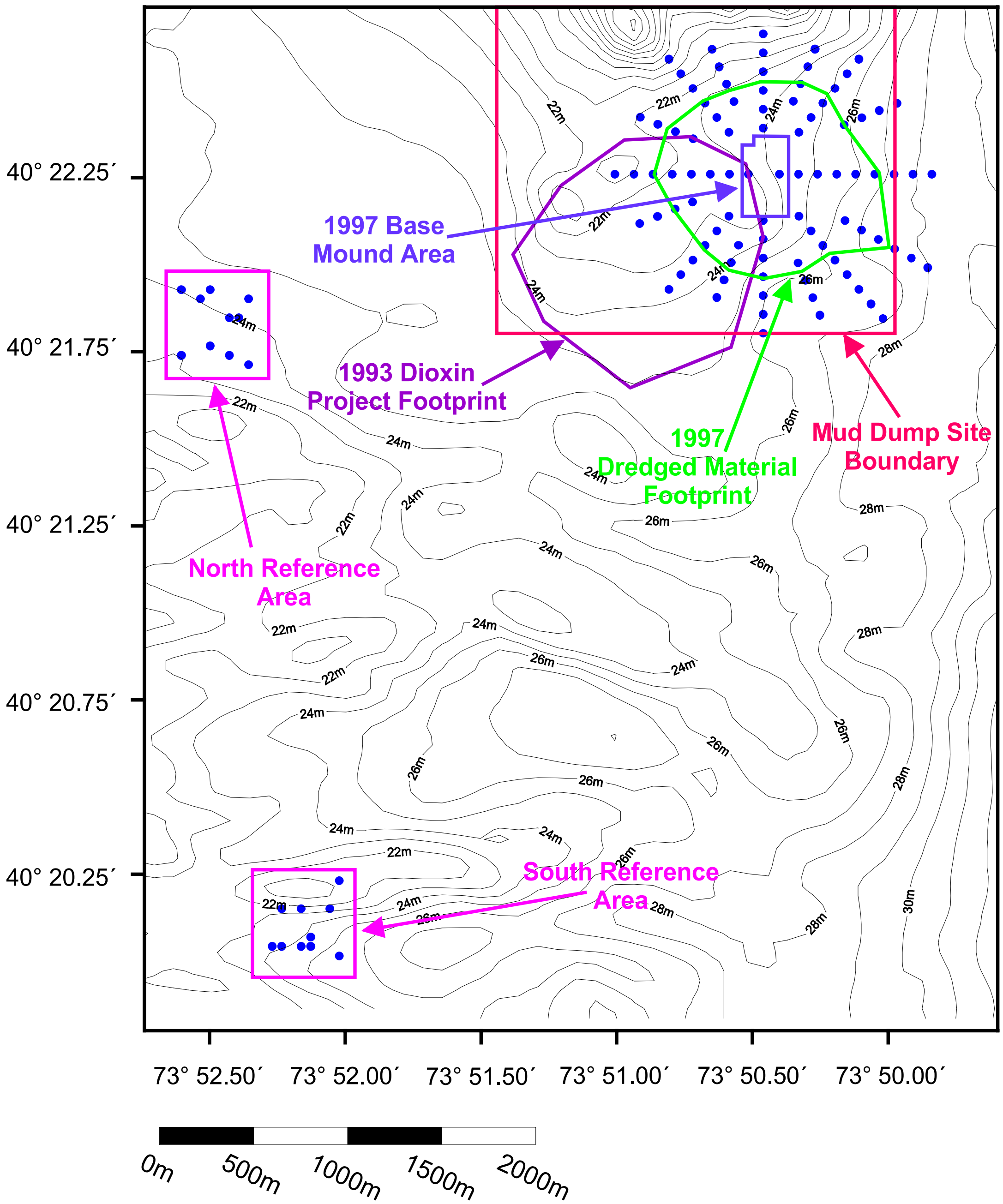


Figure 2-1. Map showing the locations of the 1997 Base Mound Area, the 1997 Category II Capping Project dredged material footprint, and the 1993 Dioxin Capping Project footprint in the southern half of the Mud Dump Site. REMOTS® station locations surrounding the 1997 Base Mound Area and in the North and South Reference Areas are also shown.

For the April 1999 postcap REMOTS® survey, a total of 110 stations were sampled in three field days during the period April 27 to April 29. Ninety of the stations were arranged in a series of radial transects centered at the 1997 Base Mound Area and extending out in all directions, to achieve the objective of sampling both the 1997 project sand cap (as delineated using high-resolution bathymetry and subbottom profiling) and the area immediately surrounding this cap (Figures 2-1 and 2-2). There were an additional 20 stations sampled within two reference areas located adjacent to the former Mud Dump Site (Figure 2-1). These are the same two reference areas sampled in previous REMOTS® surveys conducted under the 1997 Category II Capping Project (baseline, postdisposal, and postcap), as well as under the 1993 Dioxin Capping Monitoring Project (e.g., April 1994, July 1995, October 1996, and May 1997). Ten stations were sampled within each reference area (Figures 2-3 and 2-4); these stations were chosen randomly from the pool of 20 stations in each area sampled in previous REMOTS® surveys.

The 90 REMOTS® stations centered at the 1997 Base Mound Area were spaced 100 m apart along the radial transects and were distributed as follows (refer to Figures 2-1 and 2-2):

1) Roughly 22 of the stations comprising the west (W), west-southwest (WSW), southwest (SW), and south-southwest (SSW) transects occurred within or near the boundary of the 1993 Dioxin Capping Monitoring Project.

2) The outer stations of the northwest (NW), north (N) and northeast (NE) transects were located on or near several former disposal mounds located in the mid-section of the former MDS.

3) The east (E) and east-southeast (ESE) transects included both the southeast corner of the former MDS and areas up to 200 m to the east of the MDS boundaries.

The REMOTS® camera was lowered multiple times at each station in an attempt to collect at least two replicate REMOTS® images suitable for subsequent analysis. Color slide film was used and developed at the end of each field day to verify proper equipment operation and image acquisition.

2.5 REMOTS® Description

REMOTS® (Remote Ecological Monitoring Of The Seafloor) is a formal and standardized technique for sediment-profile imaging and analysis (Rhoads and Germano 1982; 1986). A Benthos Model 3731 Sediment Profile Camera (Benthos, Inc., North Falmouth, MA) was used in this study (Figure 2-5). The camera is designed to obtain *in situ* profile images of the top 20 cm of sediment. Functioning like an inverted periscope, the camera consists of a wedge-shaped prism with a front faceplate and a back mirror mounted at a 45-degree angle to reflect the profile of the sediment-water interface facing the camera. The prism is filled with distilled water, the assembly contains an internal strobe used to illuminate the images, and a 35-mm camera is mounted horizontally on top of the prism. The prism assembly is moved up and down into the sediments by producing tension or slack on the winch wire. Tension on the wire keeps the prism in the up position, out of the sediments.

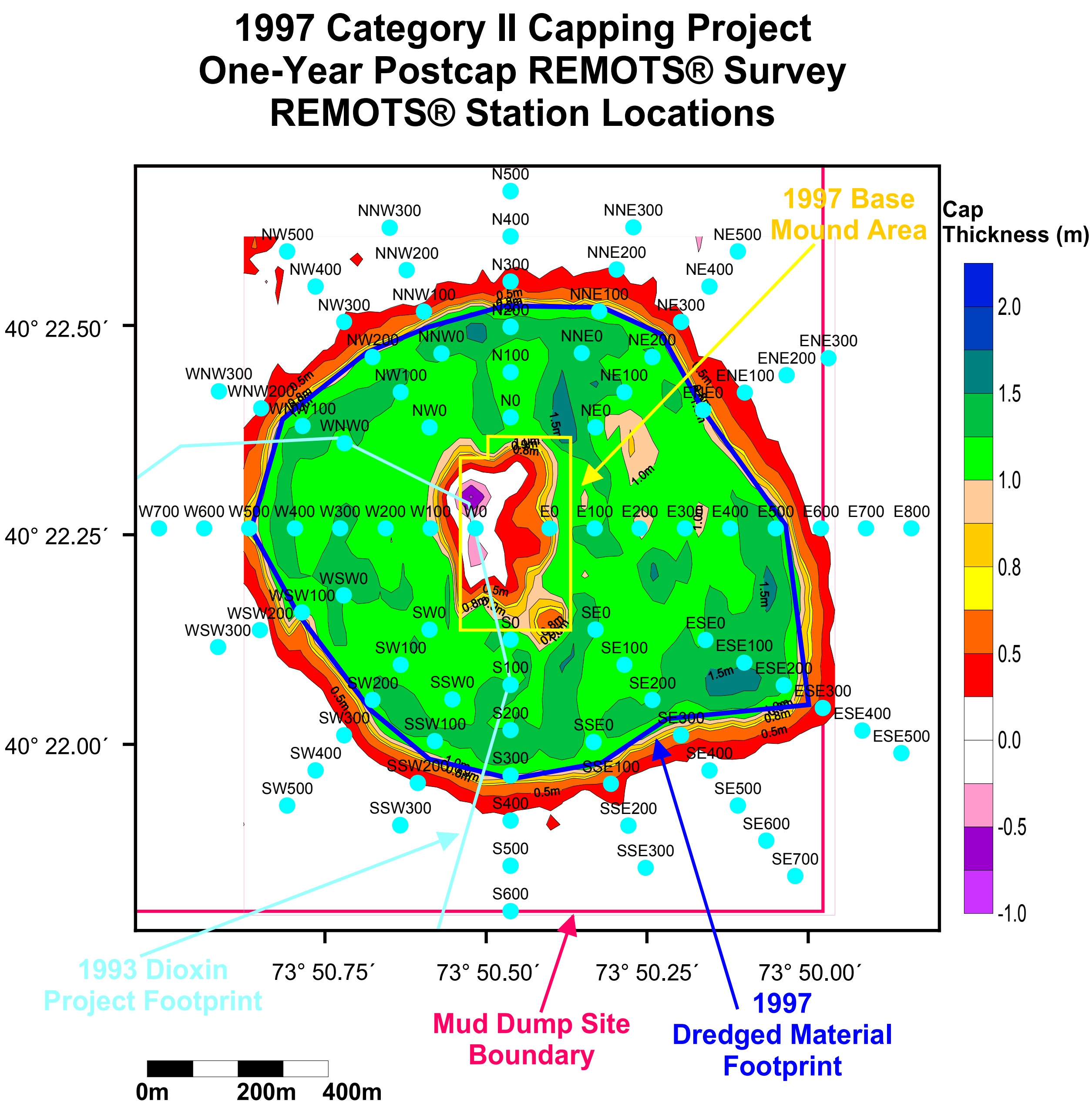


Figure 2-2. Map showing the locations of radial transect stations covering the capped project mound and surrounding area. REMOTS® sediment-profile images were obtained at each of these stations in the April 1999 one-year postcap survey. Contours showing sand cap thickness are from the April 1999 postcap bathymetric survey. Central region of minimal apparent sand cap thickness is attributed to postdredged material disposal slope adjustment (SAIC 1998A).

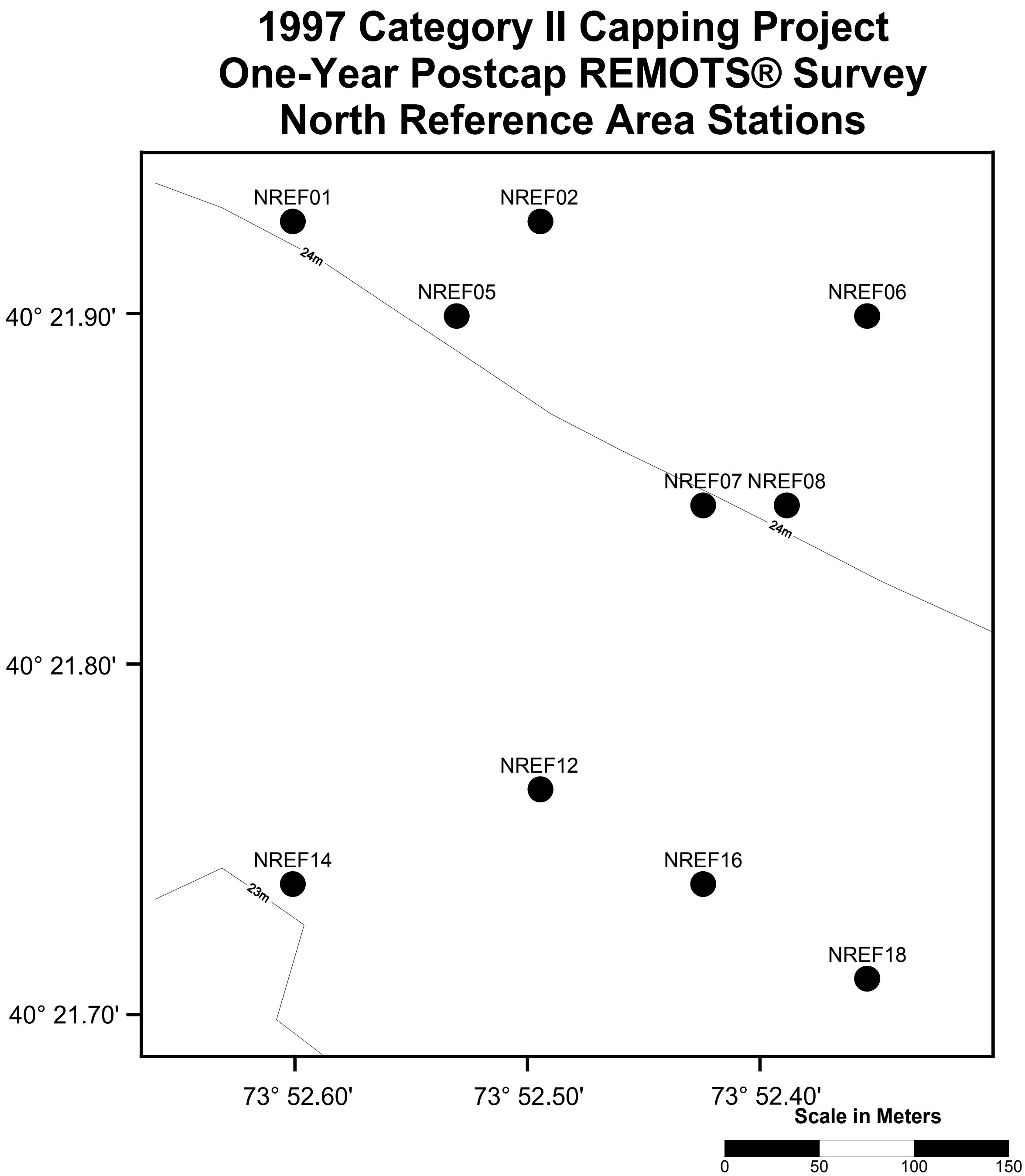


Figure 2-3. Station locations at the North Reference Area.

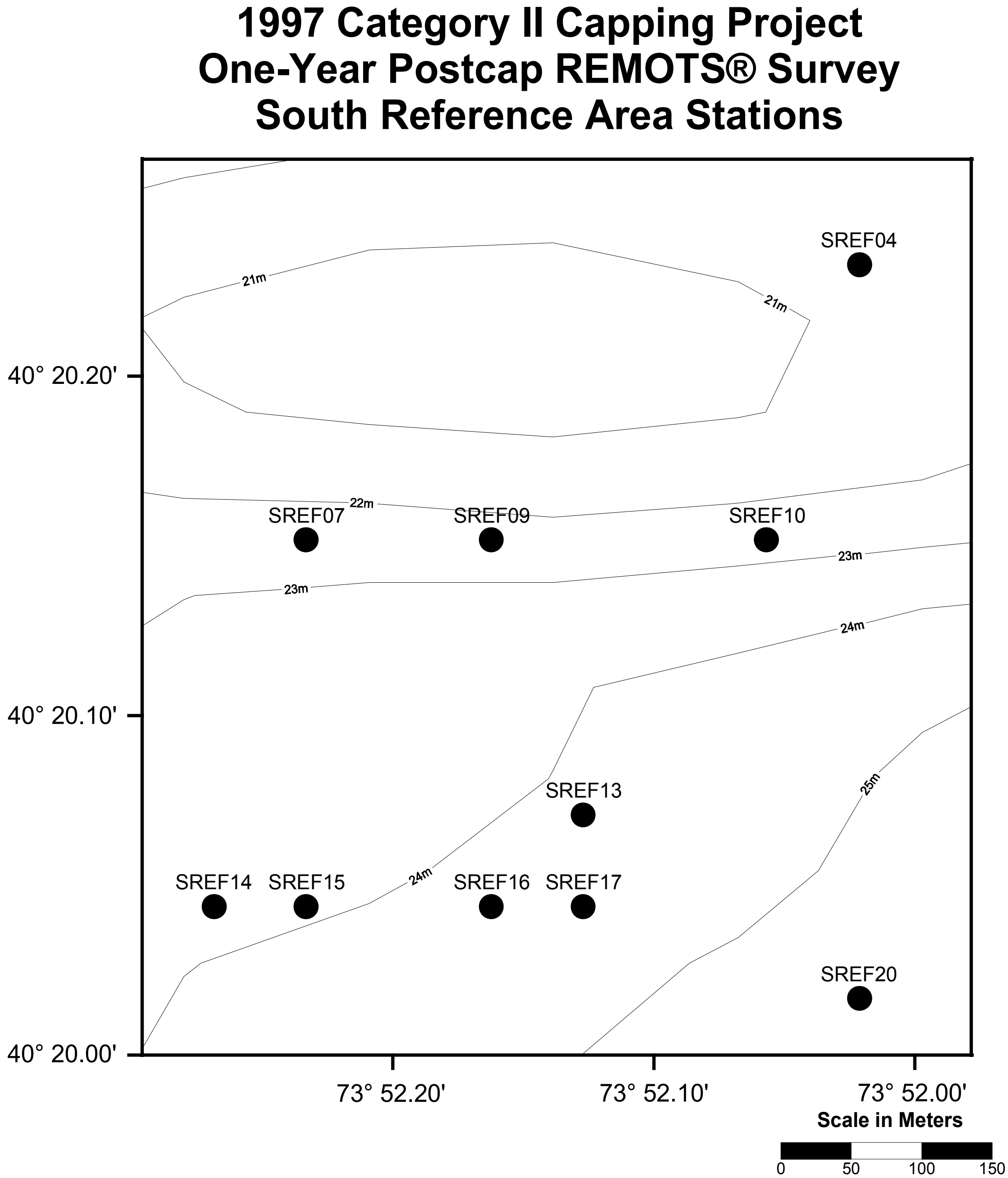


Figure 2-4. Station locations at the South Reference Area.

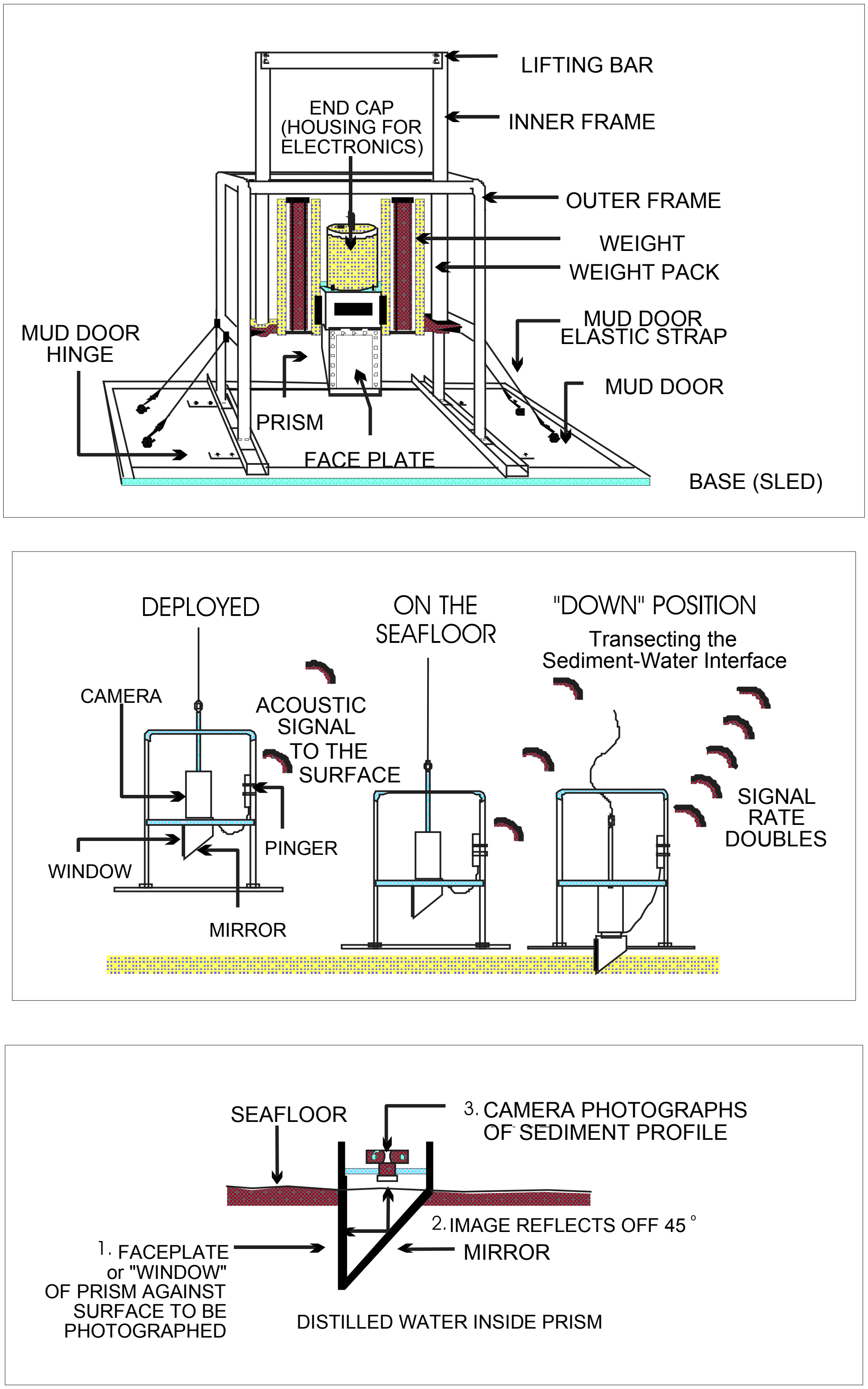


Figure 2-5. Schematic diagram of Benthos, Inc. Model 3731 REMOTS® sediment-profile camera and sequence of operation on deployment.

2.5.1 REMOTS® Image Acquisition

The camera frame is lowered to the seafloor at a rate of about 1 m/sec (Figure 2-5). When the frame settles onto the bottom, slack on the winch wire allows the prism to penetrate the seafloor vertically. A passive hydraulic piston ensures that the prism enters the bottom slowly (approximately 6 cm/sec) and does not disturb the sediment-water interface. As the prism starts to penetrate the seafloor, a trigger activates a 13-second time delay on the shutter release to allow maximum penetration before a photo is taken. A Benthos Model 2216 Deep Sea Pinger is attached to the camera and outputs a constant 12 kHz signal of one ping per second; upon discharge of the camera strobe, the ping rate doubles for 10 seconds. Monitoring the signal output on deck provides confirmation that a successful image was obtained. Because the sediment photographed is directly against the faceplate, turbidity of the ambient seawater does not affect image quality. When the camera is raised, a wiper blade cleans off the faceplate, the film is advanced by a motor drive, the strobe is recharged, and the camera can be lowered for another image.

2.5.2 REMOTS® Image Analysis

The REMOTS® images were analyzed with the full-color, SAIC Image Analysis System. This is a PC-based system integrated with a Javelin CCTV video camera and frame grabber. Color slides are digitally recorded as color images on computer disk. The image analysis software is a menu-driven program that incorporates user commands via keyboard and mouse. The system displays each color slide on the CRT while measurements of physical and biological parameters are obtained. Proprietary SAIC software allows the measurement and storage of data on up to 21 different variables for each REMOTS® image obtained. Automatic disk storage of all measured parameters allows data from any variables of interest to be compiled, sorted, displayed graphically, contoured, or compared statistically. All measurements were printed out on data sheets for a quality assurance check by an SAIC Senior Scientist before being approved for final data synthesis, statistical analyses, and interpretation. A summary of the major categories of REMOTS® data is presented below.

Sediment Type Determination

The sediment grain size major mode and range are estimated visually from the photographs by overlaying a grain size comparator which is at the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the REMOTS® camera. Seven grain size classes are on this comparator: >4 ϕ, 4-3 ϕ, 3-2 ϕ, 2-1 ϕ, 1-0 ϕ , 0-(-1) ϕ, and <-1 ϕ. The lower limit of optical resolution of the photographic system is about 62 microns (4 ϕ), allowing recognition of grain sizes equal to or greater than coarse silt. The accuracy of this method has been documented by comparing REMOTS® estimates with grain size statistics determined from traditional laboratory sieve analyses.

The major modal grain size that is assigned to an image is the dominant grain size as estimated by area within the imaged sediment column. In those images that show layering of sand and mud, the dominant major mode assigned to a replicate therefore depends on how much area of the photograph is represented by sand versus mud. A description of textural layering, if present, is included under "comments" on each data sheet (Appendix A). These textural assignments may or may not correspond to traditional sieve analyses depending on how closely the vertical sampling intervals are matched between the grab or core sample and the depth of the imaged sediment.

Sediment sorting was estimated in the following way: If all of the grain-sizes within an imaged sample fell within one Udder-Wentworth size class, the sample was classified as well sorted. If texture was distributed between (among) two (usually adjacent) Udder-Wentworth classes, the sample was described as moderately sorted. If most of the grains fell into three or more Udder-Wentworth classes, the sample was described as poorly sorted.

Boundary Roughness

Small-scale surface boundary roughness is measured from an image with the computer image analysis system. This vertical measurement is from the highest point at the sediment-water interface to the lowest point. This measurement of vertical relief is made within a horizontal distance of 15 cm (the total width of the optical window). Because the optical window is 20 cm high, the greatest possible roughness value is 20 cm. The source of the roughness is described if known. In most cases this is either biogenic (mounds and depressions formed by bioturbation or foraging activity) or relief formed by physical processes (ripples, scour depressions, rip-ups, mud clasts, etc.).

Optical Prism Penetration Depth

The optical prism penetrates the bottom under a static driving force imparted by the weight of the descending optical prism, camera housing, supporting mechanism, and weight packs. The penetration depth into the bottom depends on the force exerted by the optical prism and the bearing strength of the sediment. If the weight of the camera prism is held constant, the change in penetration depth over a surveyed site will reflect changes in geotechnical properties of the bottom. In this sense, the camera prism acts as a static-load penetrometer. The depth of penetration of the optical prism into the bottom can be a useful parameter, because dredged and capped materials often will have different shear strengths and bearing capacities than ambient sediments.

Mud Clasts

When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging), intact clumps of sediment are often scattered about the seafloor. These mud clasts can be seen at the sediment-water interface in REMOTS® images. During analysis, the number of clasts is counted, the diameter of a typical clast is measured, and their apparent oxidation state is assessed. Depending on their place of origin exposure time at the sediment-water interface, and the depth of disturbance of the sediment column, mud clasts can be reduced or oxidized. Also, once at the sediment-water interface, these sediment clumps are subject to bottom-water oxygen levels and bottom currents. Based on laboratory microcosm observations of reduced sediments placed within an aerobic environment, oxidation of reduced surface layers by molecular diffusion alone is quite rapid, occurring within 6–12 hours (Germano 1983). Consequently, the detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin. The size and shape of mud clasts, e.g., angular versus rounded, are also considered. Mud clasts may be moved about and broken by bottom currents and/or animals (macro- or meiofauna; Germano 1983). Over time, large angular clasts become small and rounded. Overall, the abundance, distribution, oxidation state, and angularity of mud clasts are used to make inferences about the recent pattern of seafloor disturbance in an area.

Measurement of Dredged Material and Cap Layers

The recognition of dredged material from REMOTS® images is usually based on the presence of anomalous sedimentary materials within an area of ambient sediment. The ability to distinguish between ambient sediment and dredged or cap material demands that the survey extend well beyond the margins of a disposal site so that an accurate characterization of the ambient bottom is obtained. The distributional anomalies may be manifested in topographic roughness, differences in grain size, sorting, shell content, optical reflectance, fabric, or sediment compaction (i.e., camera prism penetration depth). Second-order anomalies may also provide information about the effects of dredged material on the benthos and benthic processes such as bioturbation and successional status (see following sections).

Apparent Redox Potential Discontinuity (RPD) Depth

Aerobic near-surface marine sediments typically have higher reflectance values relative to underlying anoxic sediments. Sand also has higher optical reflectance than mud. These differences in optical reflectance are readily apparent in REMOTS® images; the oxidized surface sediment contains particles coated with ferric hydroxide (an olive color when associated with particles), while reduced and muddy sediments below this oxygenated layer are darker, generally grey to black. The boundary between the colored ferric hydroxide surface sediment and underlying grey to black sediment is called the apparent redox potential discontinuity (RPD).

The depth of the apparent RPD in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters. In the absence of bioturbating organisms, this high reflectance layer (in muds) will typically reach a thickness of 2 mm (Rhoads 1974). This depth is related to the supply rate of molecular oxygen by diffusion into the bottom and the consumption of that oxygen by the sediment and associated microflora. In sediments that have very high sediment-oxygen demand, the sediment may lack a high reflectance layer even when the overlying water column is aerobic.

In the presence of bioturbating macrofauna, the thickness of the high reflectance layer may be several centimeters. The relationship between the thickness of this high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be made with caution. The boundary (or horizon) which separates the positive Eh region (oxidized) from the underlying negative Eh region (reduced) can only be determined accurately with microelectrodes. For this reason, we describe the optical reflectance boundary, as imaged, as the "apparent" RPD, and it is mapped as a mean value.

The depression of the apparent RPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day); therefore, this parameter has a long time constant (Germano and Rhoads 1984). The rebound in the apparent RPD is also slow (Germano 1983). Measurable changes in the apparent RPD depth using the REMOTS® optical technique can be detected over periods of one or two months. This parameter is used effectively to document changes (or gradients) which develop over a seasonal or yearly cycle related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment. In sediment-profile surveys of ocean disposal sites sampled seasonally or on an annual basis throughout the New England region performed under the DAMOS (Disposal Area Monitoring System) Program for the U.S. Army Corps of Engineers, New England Division, SAIC repeatedly has documented a drastic reduction in apparent RPD depths at disposal sites immediately after dredged material disposal, followed by a progressive postdisposal apparent RPD deepening (barring further physical disturbance). Consequently, time-series RPD measurements can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos.

The depth of the mean apparent RPD also can be affected by local erosion. The peaks of disposal mounds commonly are scoured by divergent flow over the mound. This can result in washing away of fines, development of shell or gravel lag deposits, and very thin apparent RPD depths. During storm periods, erosion may completely remove any evidence of the apparent RPD (Fredette et al. 1988).

Another important characteristic of the apparent RPD is the contrast in reflectance values at this boundary. This contrast is related to the interactions among the rate of organic-loading, bioturbational activity in the sediment, and the concentration of bottom-water dissolved oxygen in an area. High inputs of labile organic material increase sediment oxygen demand and, subsequently, sulfate reduction rates (and the abundance of sulfide end-products). This results in more highly reduced (lower reflectance) sediments at depth and higher RPD contrasts. In a region of generally low RPD contrasts, images with high RPD contrasts indicate localized sites of relatively high past inputs of organic-rich material (e.g., organic or phytoplankton detritus, dredged material, sewage sludge, etc.).

Sedimentary Methane

At extreme levels of organic-loading, pore-water sulfate is depleted, and methanogenesis occurs. The process of methanogenesis is detected by the appearance of methane bubbles in the sediment column. These bubbles are detected when they reach a size of ≥1 mm (lower limit of optical detection). These gas-filled voids are readily discernible in REMOTS® images because of their irregular, generally circular aspect and glassy texture (due to the reflection of the strobe off the gas). If present, the number and total areal coverage of all methane pockets are measured.

Infaunal Successional Stages

The mapping of successional stages, as employed in this project, is based on the theory that organism-sediment interactions in fine-grained sediments follow a predictable sequence after a major seafloor perturbation (e.g., passage of a storm, disturbance by bottom trawlers, dredged material deposition, hypoxia). This theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest, our definition does not demand a sequential appearance of particular invertebrate species or genera" (Rhoads and Boyer 1982). This theory is formally developed in Rhoads and Germano (1982; 1986) and Rhoads and Boyer (1982).

The term disturbance is used here to define natural processes, such as seafloor erosion, changes in seafloor chemistry, and foraging disturbances which cause major reorganization of the resident benthos; disturbance also includes anthropogenic impacts, such as dredged material or sewage sludge disposal, thermal effluent from power plants, bottom trawling, pollution impacts from industrial discharge, etc. An important aspect of using this successional approach to interpret benthic monitoring results is relating organism-sediment relationships to the dynamical aspects of end-member successional stages (i.e., Stage I, II, or III communities as defined in the following paragraphs). This involves deducing dynamics from structure, a technique pioneered by R. G. Johnson (1972) for marine soft-bottom habitats. The application of this approach to benthic monitoring requires *in situ* measurements of salient structural features of organism-sediment relationships as imaged through REMOTS® technology.

Pioneering assemblages (Stage I assemblages) usually consist of dense aggregations of near-surface living, tube-dwelling polychaetes; alternately, opportunistic bivalves may colonize in dense aggregations after a disturbance (Rhoads and Germano 1982, Santos and Simon 1980a). These functional types are usually associated with a shallow redox boundary; bioturbation depths are shallow, particularly in the earliest stages of colonization (Figure 2-6). In the absence of further disturbance, these early successional assemblages are eventually replaced by infaunal deposit feeders; the start of this "infaunalization" process is designated arbitrarily as Stage II. Typical Stage II species are shallow dwelling bivalves or, as is common in New England waters, tubicolous amphipods. In studies of hypoxia-induced benthic defaunation events in Tampa Bay, Florida, ampeliscid amphipods appeared as the second temporal dominant in two of the four recolonization cycles (Santos and Simon 1980a, 1980b).

Stage III taxa, in turn, represent high-order successional stages typically found in low-disturbance regimes. These invertebrates are infaunal, and many feed at depth in a head-down orientation. The localized feeding activity results in distinctive excavations called feeding voids (Figure 2-6). Diagnostic features of these feeding structures include a generally semicircular shape with a flat bottom and arched roof, and a distinct granulometric change in the sediment particles overlying the floor of the structure. This granulometric change is caused by the accumulation of coarse particles that are rejected by the animals feeding selectively on fine-grained material. Other subsurface structures, such as burrows or methane gas bubbles, do not exhibit these characteristics and therefore are quite distinguishable from these distinctive feeding structures. The bioturbational activities of these deposit-feeders are responsible for aerating the sediment and causing the redox horizon to be located several centimeters below the sediment-water interface. In the retrograde transition of Stage III to Stage I, it is sometimes possible to recognize the presence of relic (i.e., collapsed and inactive) feeding voids.

The end-member stages (Stages I and III) are easily recognized in REMOTS® images by the presence of dense assemblages of near-surface polychaetes and the presence of subsurface feeding voids, respectively (Figure 2-6); both types of assemblages may be present in the same image (e.g., Stage I on III). Additional information on REMOTS® image interpretation can be found in Rhoads and Germano (1982, 1986).

Organism-Sediment Index (OSI)

The multi-parameter REMOTS® Organism-Sediment Index (OSI) has been constructed to characterize habitat quality. Habitat quality is defined relative to two end-member standards. The lowest value is given to those bottoms which have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (see Rhoads and Germano 1982, 1986, for REMOTS® criteria for these conditions). The OSI for such a condition is -10. At the other end of the scale, an aerobic bottom with a deeply depressed RPD, evidence of a mature macrofaunal assemblage (e.g., Stage III), and no apparent methane gas bubbles at depth will have an OSI value of +11.

The OSI is a sum of the subset indices shown in Table 2-1. The OSI is calculated automatically by SAIC software after completion of all measurements from each REMOTS® photographic slide. The index has proven to be an excellent parameter for mapping disturbance gradients in an area and documenting ecosystem recovery after disturbance (Germano and Rhoads 1984, Revelas et al. 1987, Valente et al. 1992).

The OSI may be subject to seasonal changes because the mean apparent RPD depths vary as a result of temperature-controlled changes of bioturbation rates solubility of oxygen in water, and sediment oxygen demand. Furthermore, the successional status of a station may change over the course of a season related to recruitment and mortality patterns or the disturbance history of the bottom. The sub-annual change in successional status is generally limited to Stage I (Polychaete-dominated) and Stage II (amphipod-dominated) seres. Stage III seres tend to be maintained over periods of several years unless they are eliminated by increasing organic loading, extended periods of hypoxia, or burial by thick layers of dredged material. The recovery of Stage III seres following abatement of such events may take several years (Rhoads and Germano 1982). Stations that have low OSI values (<+6) are indicative of recently disturbed areas and tend to have greater temporal and spatial variation in benthic habitat quality than stations with higher OSI values (≥+6).

Table 2-1

Calculation of REMOTS® Organism-Sediment Index Value

A. CHOOSE ONE VALUE:

Mean RPD Depth	Index Value
0.00 cm	0
> 0 - 0.75 cm	1
0.75 - 1.50 cm	2
1.51 - 2.25 cm	3
2.26 - 3.00 cm	4
3.01 - 3.75 cm	5
> 3.75 cm	6

B. CHOOSE ONE VALUE:

Successional Stage	Index Value
Azoic	-4
Stage I	1
Stage I to II	2
Stage II	3
Stage II to III	4
Stage III	5
Stage I on III	5
Stage II on III	5

C. CHOOSE ONE OR BOTH IF APPROPRIATE:

Chemical Parameters	Index Value
Methane Present	-2
No/Low Dissolved Oxygen**	-4

REMOTS® ORGANISM-SEDIMENT INDEX = Total of above subset indices (A+B+C)

RANGE: -10 - +11

** Note: This is not based on a Winkler or polarigraphic electrode measurement. It is based on the imaged evidence of reduced, low reflectance (i.e., high oxygen demand) sediment at the sediment-water interface.

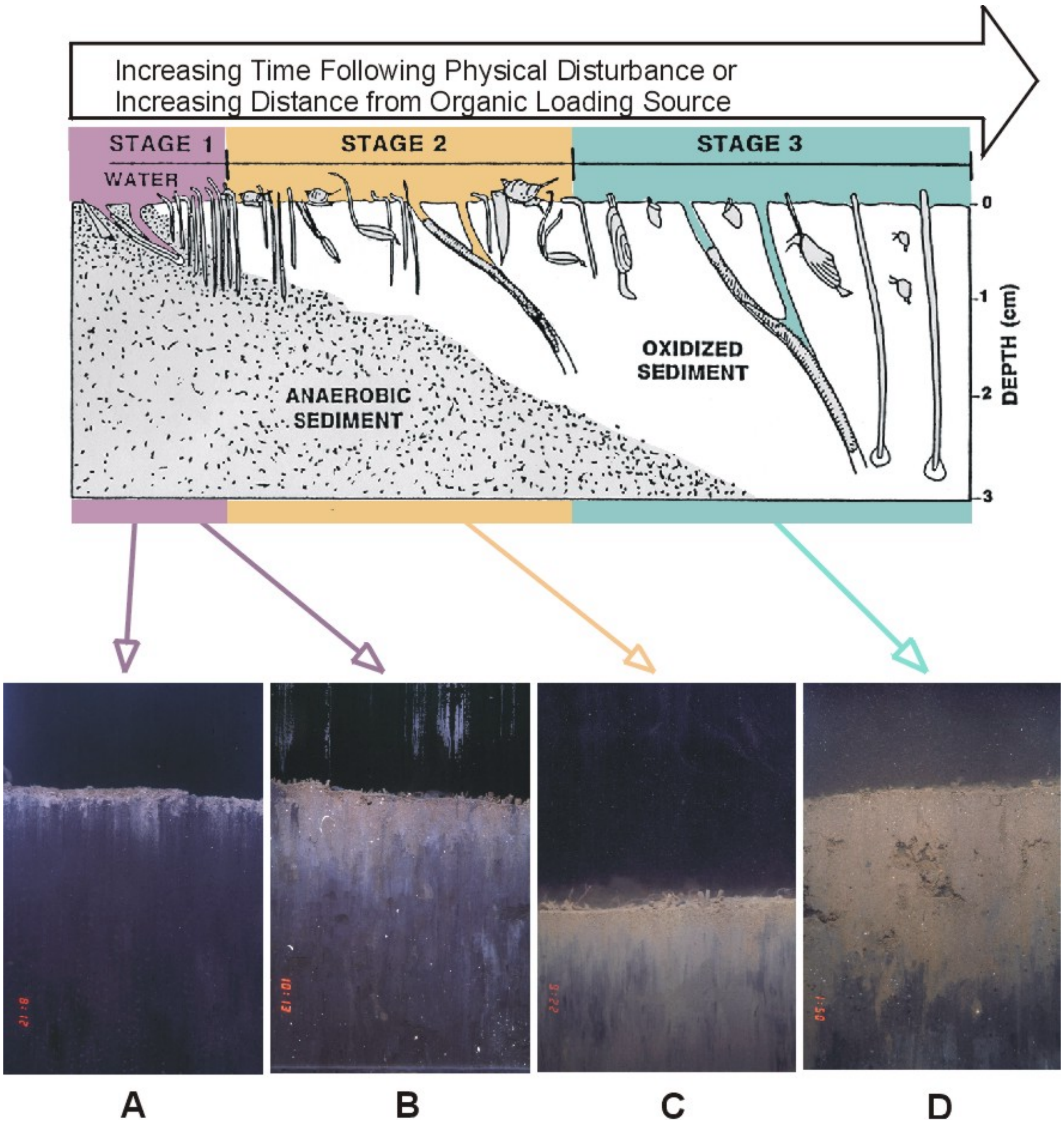


Figure 2-6. The drawing at the top illustrates the development of infaunal successional stages over time following a physical disturbance or with distance from an organic loading source (from Rhoads and Germano 1986). The REMOTS® images below the drawing provide examples of the different successional stages. Image A shows highly reduced sediment with a very shallow redox layer (contrast between light colored surface sediments and dark underlying sediments) and little evidence of infauna. Numerous small polychaete tubes are visible at the sediment surface in image B (Stage I), and the redox depth is deeper than in image A. A mixture of polychaete and amphipod tubes occurs at the sediment surface in image C (Stage II). Image D shows numerous burrow openings and feeding pockets (voids) at depth within the sediment; these are evidence of deposit-feeding, Stage III infauna. Note the RPD is relatively deep in this image, as bioturbation by the Stage III organisms has resulted in increased sediment aeration.

3.0 BATHYMETRIC SURVEY RESULTS

The one-year postcap bathymetric survey results are presented in a variety of graphic data products to illustrate the topography of the study area. All graphic data products have been plotted in NAD83 latitude/longitude coordinates, and depth values are relative to Mean Lower Low Water (MLLW). The 1997 Category II Capping Project area is located in the southeast quadrant of the former MDS, south of the large mounds in the central MDS. Figure 3-1 presents a two-dimensional color bathymetric plot of the topography within the study area from data collected in August 1997, immediately following the completion of the dredged material disposal phase of the project and immediately prior to the beginning of the capping phase. Figure 3-2 is identical in format to Figure 3-1 but presents the April 8, 1998 postcap topography (i.e. two months following the completion of the capping phase). Water depths are indicated with a contour interval of 2 feet, relative to MLLW. The 65-ft depth contour shown in these figures represents the minimum depth design criteria for the mound. For reference, the 1997 base mound area (the target cells where disposal scows were directed to place the dredged material) and the disposed material footprint are identified.

Figure 3-3 is a two-dimensional color plot of bathymetric contours within the survey area generated from the results of the April 1, 1999 one-year postcap survey topography (i.e. fourteen months following the completion of the capping operation). The topography of the project area ranged from 64.5 feet at the peak of the project mound near the southwest corner of the base mound area, to greater than 90 feet at the southeast corner of the survey area. A small but noticeable bathymetric change between the April 1998 postcap survey (Figure 3-2) and the April 1999 one-year postcap survey (Figure 3-3), was the apparent accumulation of material at the apex of the mound in the southwest quadrant of the base mound area. However, the difference is only about 0.5 ft, which lies within the resolution limits of the survey equipment used. The resolution limits of the survey equipment along with uncontrollable variables such as sea state and vessel stability combine to form “survey artifacts.” These artifacts lie within the range of +/-0.5-1.0 ft and therefore data within this range are not given much weight. Generally speaking, the comparison of Figures 3-2 and 3-3 suggests little significant change had occurred in the topography of the sand cap over the one year period between the immediate postcap (April 1998) and one-year postcap (April 1999) bathymetric surveys.

Three-dimensional contour plots are helpful for graphically portraying the topography of the survey area. For example, Figure 3-4 presents a three-dimensional view of the study area, facing northwestward. The KVK historical dredged material mound in the northwest corner of the survey area appears relatively steep, a result of the vertical exaggeration in the figure. The depth axis in this figure has been stretched by a factor of 43:1 to exaggerate the topography of the existing capped mound.

Gridded data from the two bathymetric surveys were compared by algebraically subtracting the April 1998 postcap data, used as the baseline grid, from the April 1999 one-year postcap grid. A two-dimensional color plot of the depth difference results between the two surveys is presented in Figure 3-5. This figure effectively illustrates that there has been little to no change in seafloor

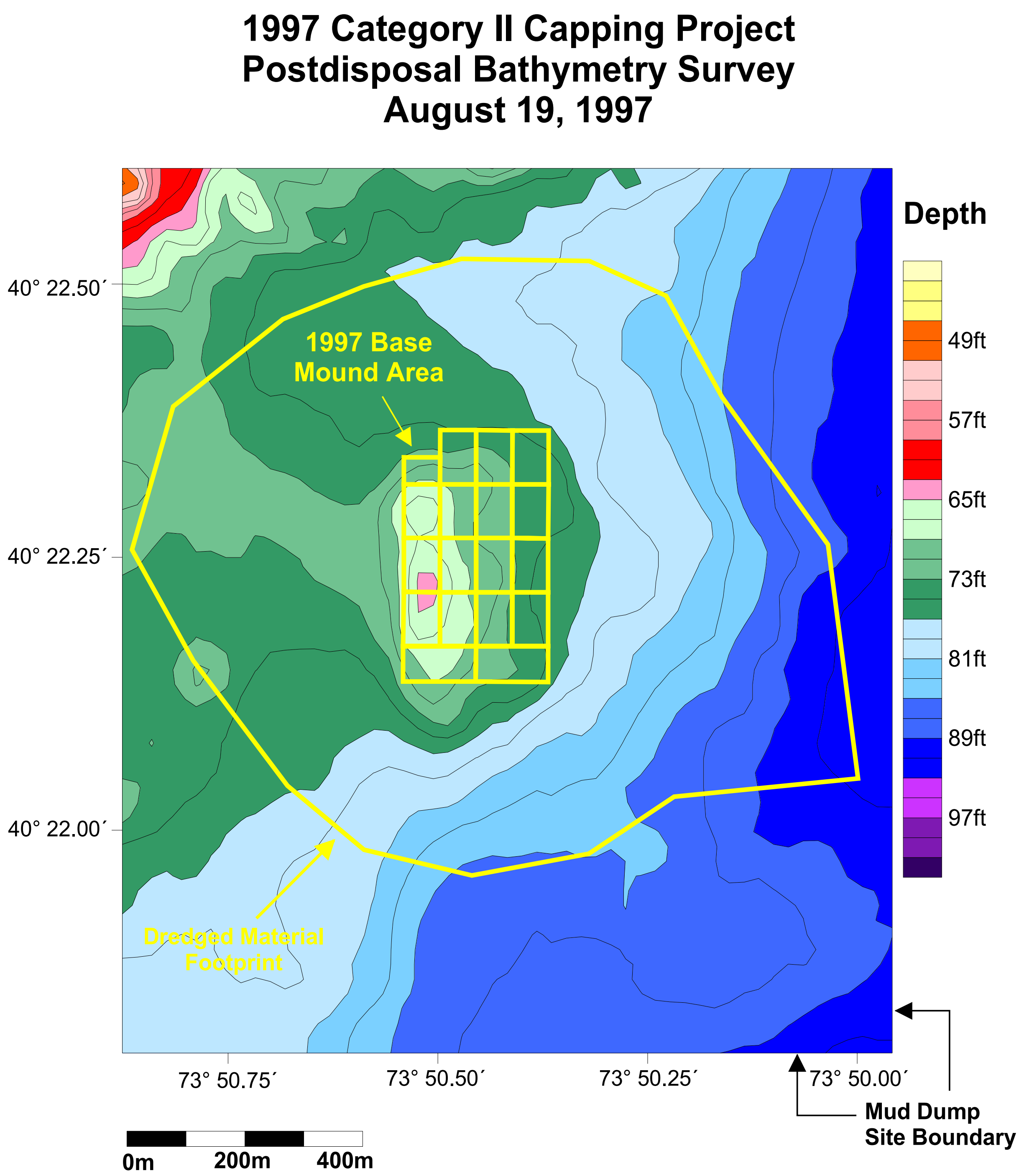


Figure 3-1. Two-dimensional color plot of topographic features from the August 1997 bathymetry survey of the Category II dredged material mound. This survey was conducted immediately following the completion of the disposal operation. The dredged material disposal cells (1997 Base Mound Area) and footprint have been plotted for reference.

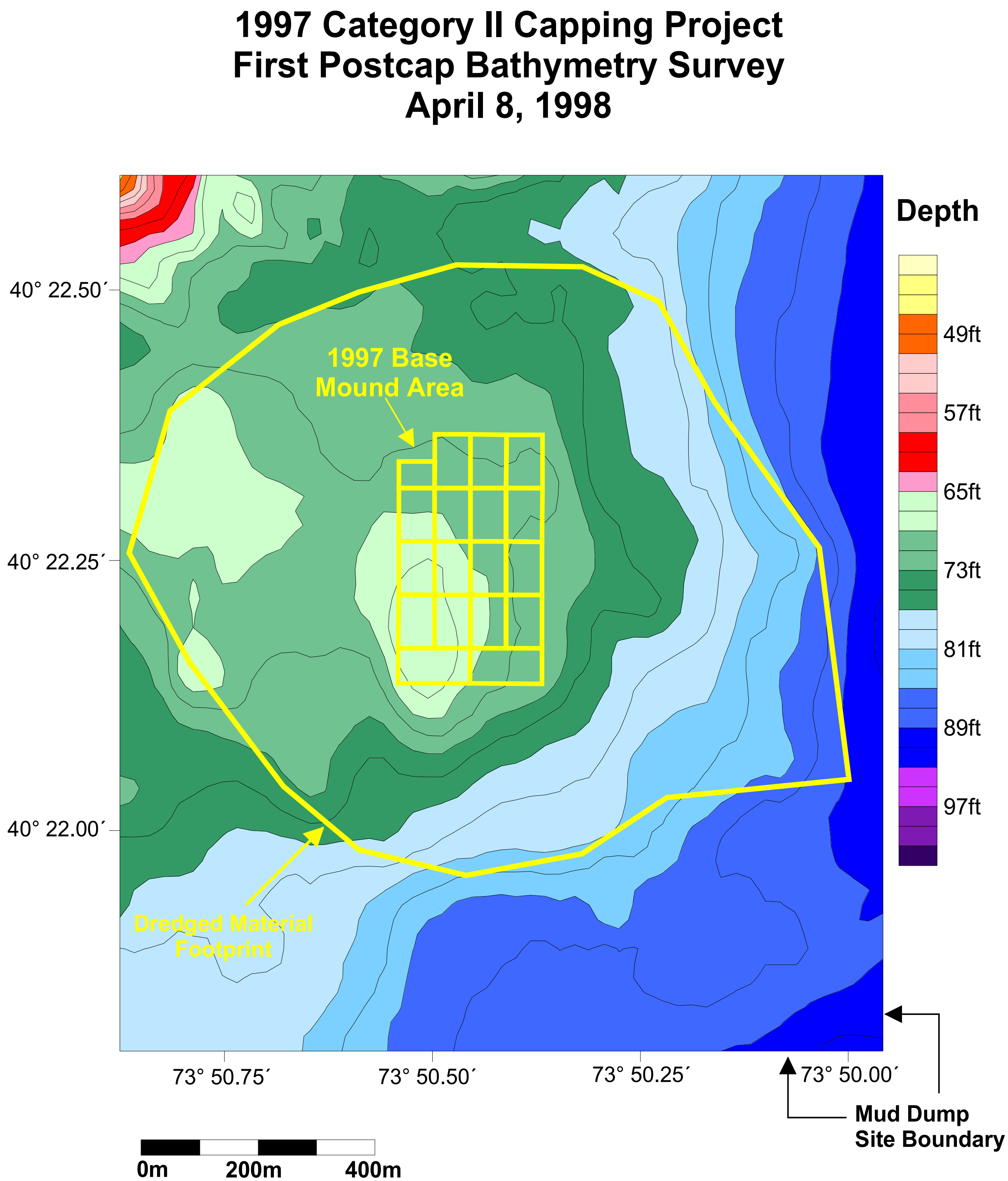


Figure 3-2. Two-dimensional color contour of topographic features from the April 1998 postcap bathymetry survey of the Category II capping project. The dredged material disposal cells (1997 Base Mound Area) and footprint have been plotted for reference.

1997 Category II Capping Project
One-Year Postcap Bathymetry Survey
April 1, 1999

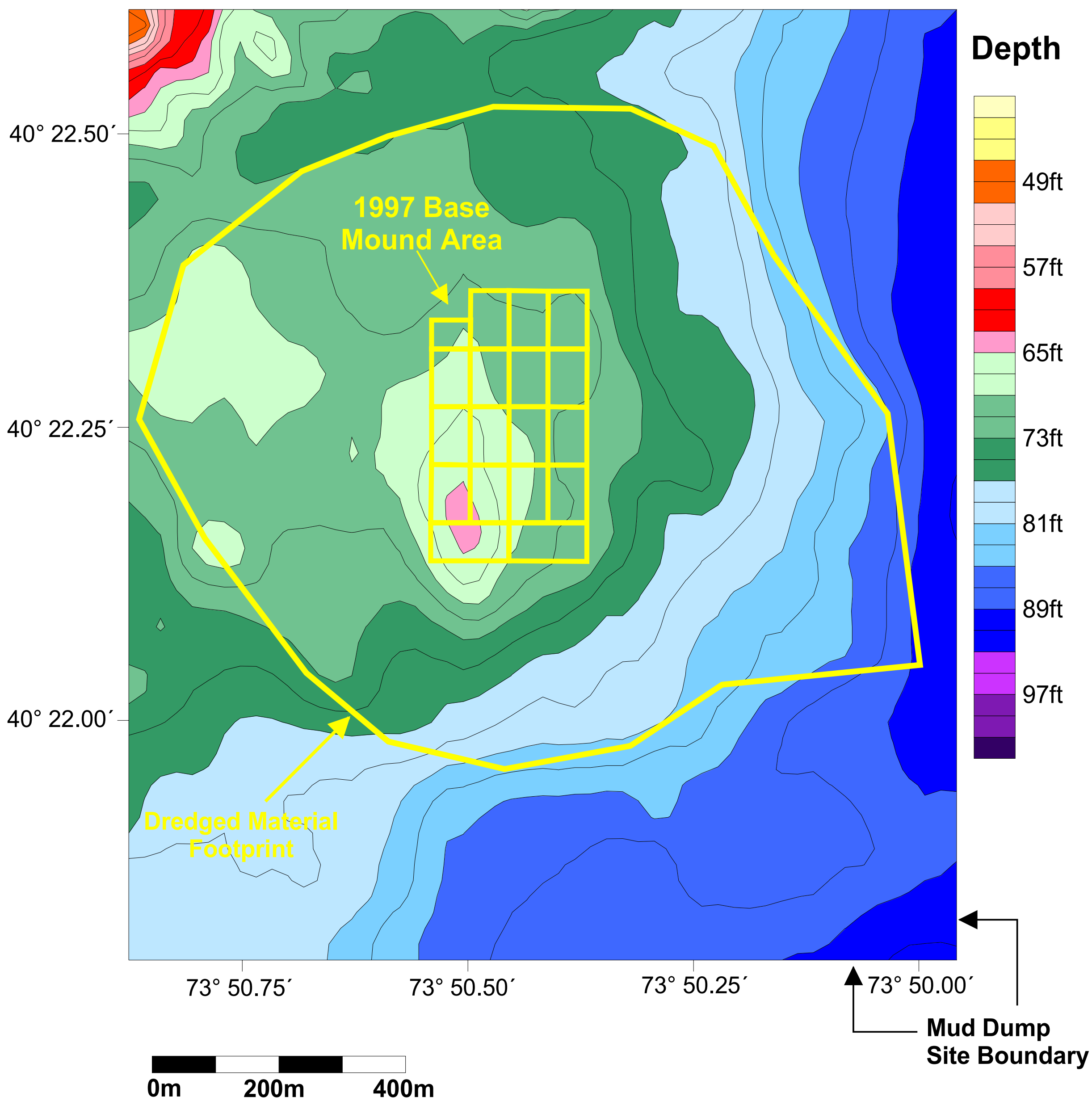


Figure 3-3. Two-dimensional color contour of topographic features from the April 1999 one-year postcap bathymetry survey of the Category II capping project. The dredged material disposal cells (1997 Base Mound Area) and footprint have been plotted for reference.

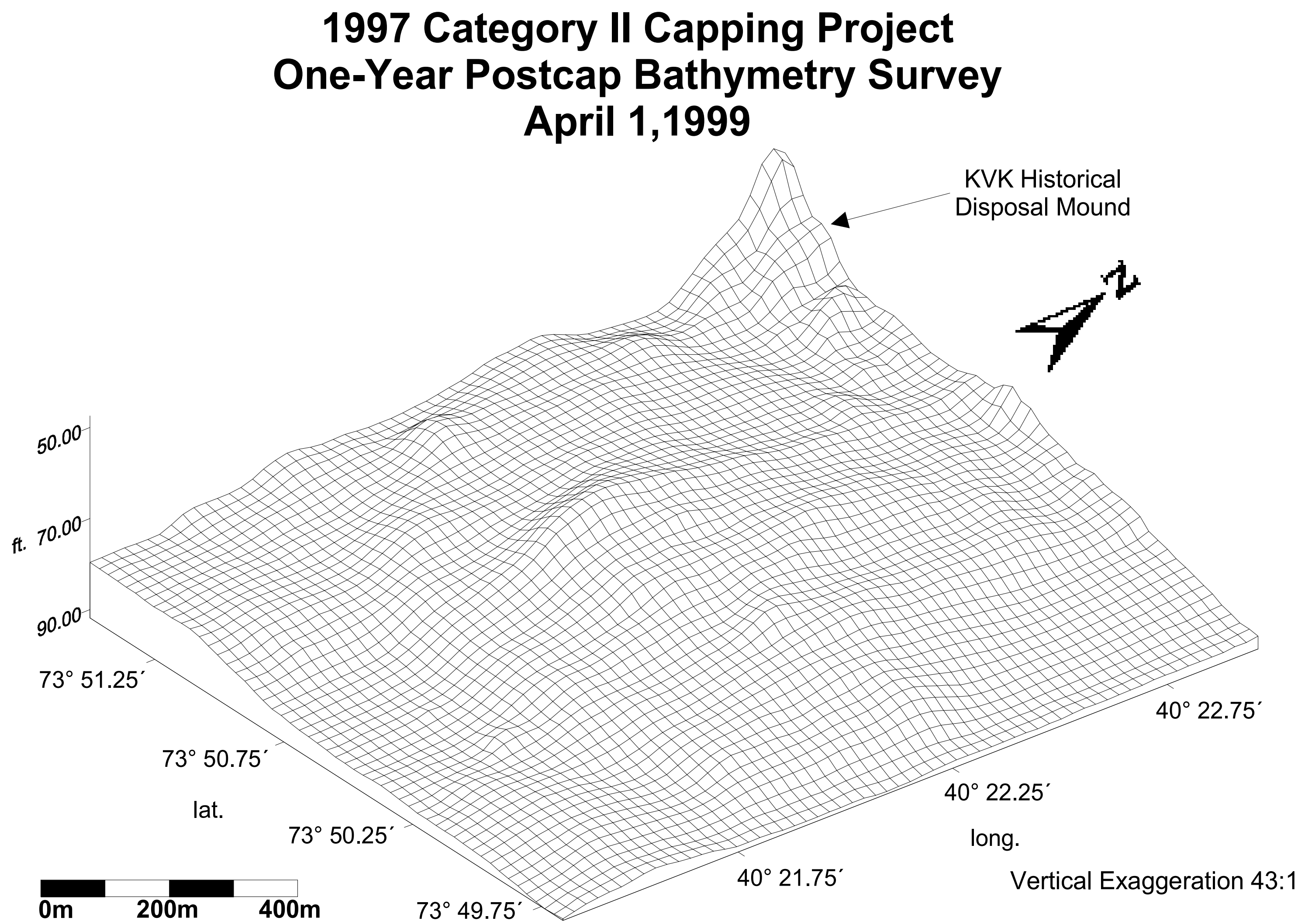


Figure 3-4. Three-dimensional plot of the April 1999 one-year postcap bathymetry data.

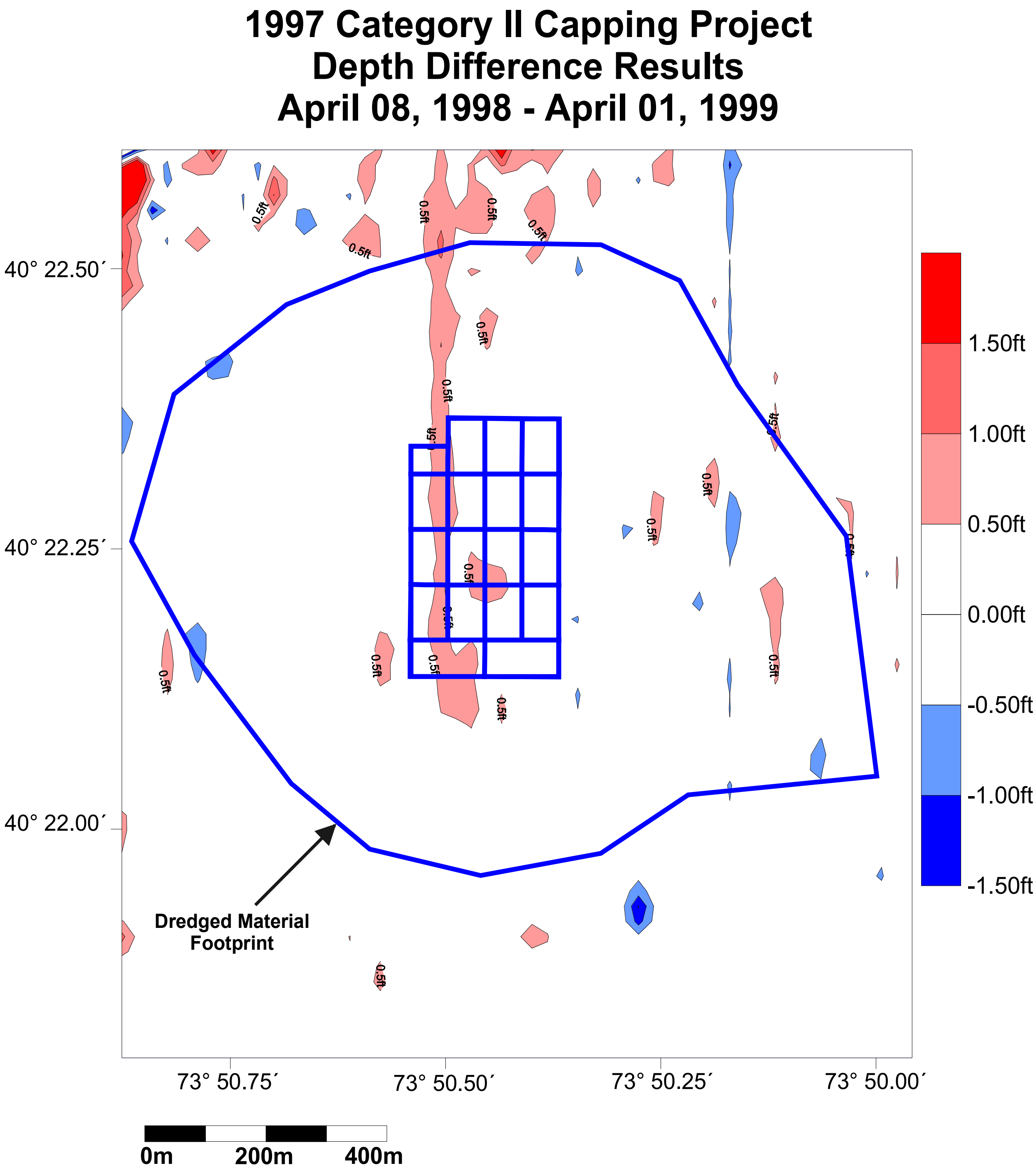


Figure 3-5. Two-dimensional plot of depth difference values between the April 1998 postcap and April 1999 one-year postcap bathymetric surveys.

topography over the project area. The majority of the differences seen in the figure are within the +/-0.5-1.0 ft resolution limit (i.e. within the noise). The 0.5 ft contour in red that extends down from the north through the western portion of the base mound area suggests that the possible accumulation referred to previously in Figure 3-3 is indeed within the survey resolution limits.

Figure 3-6 illustrates the depth difference results between bathymetric surveys conducted at the end of disposal operations (postdisposal August 19, 1997) and one year after capping operations had concluded (one-year postcap April 1, 1999 survey). Within the base mound region, a large area of negative depth difference values (-1 m) was observed in the western portion of the base mound area. This region corresponds with the portion of the dredged material mound that has been dubbed "Creamer's Ridge" by Thomas M. Creamer temporarily assigned to the NYD for this project. Negative difference values generally indicate a loss of material, however, in this case the negative difference values were the result of a postdisposal slope adjustment and consolidation of the project mound. Results from a subbottom profile survey conducted by SAIC on September 5, 1997, confirmed that the disposal mound underwent a slope adjustment but no material was lost from the project area (SAIC 1998a). Because sequential bathymetric depth differencing techniques could not be used to determine the sand thickness in the region of the slope adjustment, the PANY/NJ conducted an interim-cap subbottom profile survey over the slope-adjusted mound and verified that a 1 m cap had been placed in the area. A subbottom survey of the entire area conducted by SAIC for the NYD on April 26–27, 1998, also served to confirm that a 1-m thick layer of sand was distributed uniformly over the entire project area (SAIC 1998b).

A total of 1,477 25 m^2 cells lie within the dredged material footprint. Figure 3-7 is a histogram plot of sediment accumulation percentage within the footprint area based on a comparison of the April 1998 and April 1999 bathymetric surveys. The blue bar indicates percent area with change in thickness values less than 0.5 m and red indicates percentages with values of 0.5 or more meters of accumulation. The bathymetric results suggest that as of April 1999, 93% of the capping area within the footprint had no significant change (+/-0.5 m) in the detected thickness of the sand cap.

The depth difference results between the April 1998 postcap and April 1999 one-year postcap surveys yielded a calculated net volume change of +62,206 yd^3 of sediment. This volume is considered inconsequential relative to the size of the survey area (2,332,408 yd^2) and is attributed to a combination of survey artifacts and random settlement.

In addition to the 52 north-south bathymetric survey lines, seven of the 17 east-west crosslines occupied during baseline studies were resurveyed during the one-year postcap survey. These lines were centered on the 1997 base mound area and spaced 50 m apart (Figure 3-8). Soundings from these crosslines were edited and corrected in the same manner as for data from the north-south lines. Figures 3-9 through 3-15 illustrate depth profiles from the crosslines labeled 6 through 12, with water depth plotted on the vertical axis and Easting coordinates (NAD 83 State Plane, zone 3104 - Long Island) plotted on the horizontal axis, both in units of feet. In the individual profile plots, the April 23, 1997, baseline bathymetric data were included along with the postdisposal (August 19, 1997) data, the postcap (April 8, 1998) data, and the one-year postcap (April 1, 1999) data, to clearly show the location and elevation of the dredged material accumulation and the overlying sand cap material. Note, however, that a vertical exaggeration of 103:1 has been applied to the depth profiles to enhance the topographic representation.

The trackplots generated from the crossline data present a time-series display of the topographic changes that have occurred in the study site as a result of the disposal and subsequent capping of Category II material. Beginning with the predisposal April 1997 baseline data (red) and ending with the April 1999 one-year postcap data (black) the growth of the dredged material disposal mound and cap is clearly represented. Following the completion of disposal operations and prior to capping, the Category II dredged material mound extended as much as 12 ft above the predisposal conditions as indicated with the August 1997 postdisposal profile data (green).

On the flanks of the disposal mound, east and west of the mound peak, the April 1998 (blue) and April 1999 (black) postcap profile data provide supporting evidence that a uniformly distributed, 1 m thick layer of capping sand was placed over the Category II dredged material footprint. The profile data suggest that near the peak of the dredged material mound there was little to no cap layer. This however is an artifact of a slope adjustment that occurred following the August 1997 postdisposal bathymetric survey. Evidence that the meta-stable dredged material underwent a slope adjustment was provided by a subbottom profile survey conducted for the NYD by SAIC in September 1997 (SAIC 1998b). In each of the crosslines surveyed, the April 1999 profile data (black) closely corresponds the with April 1998 (blue), profile providing further evidence that there has been little to no change in the topography of the capped mound.

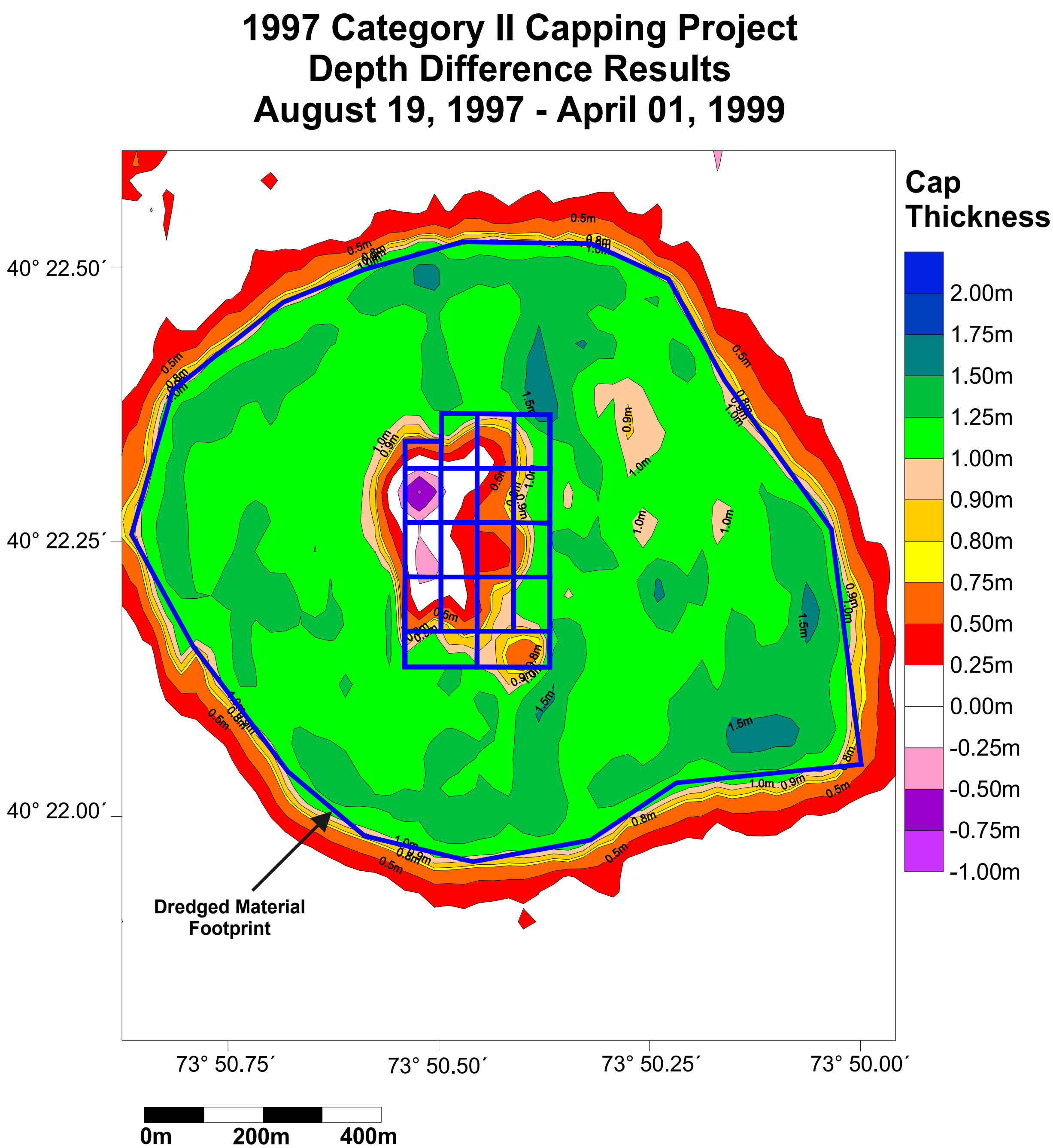


Figure 3-6. Color plot of depth difference results between the August 1997 postdisposal and April 1999 one-year postcap bathymetry surveys.

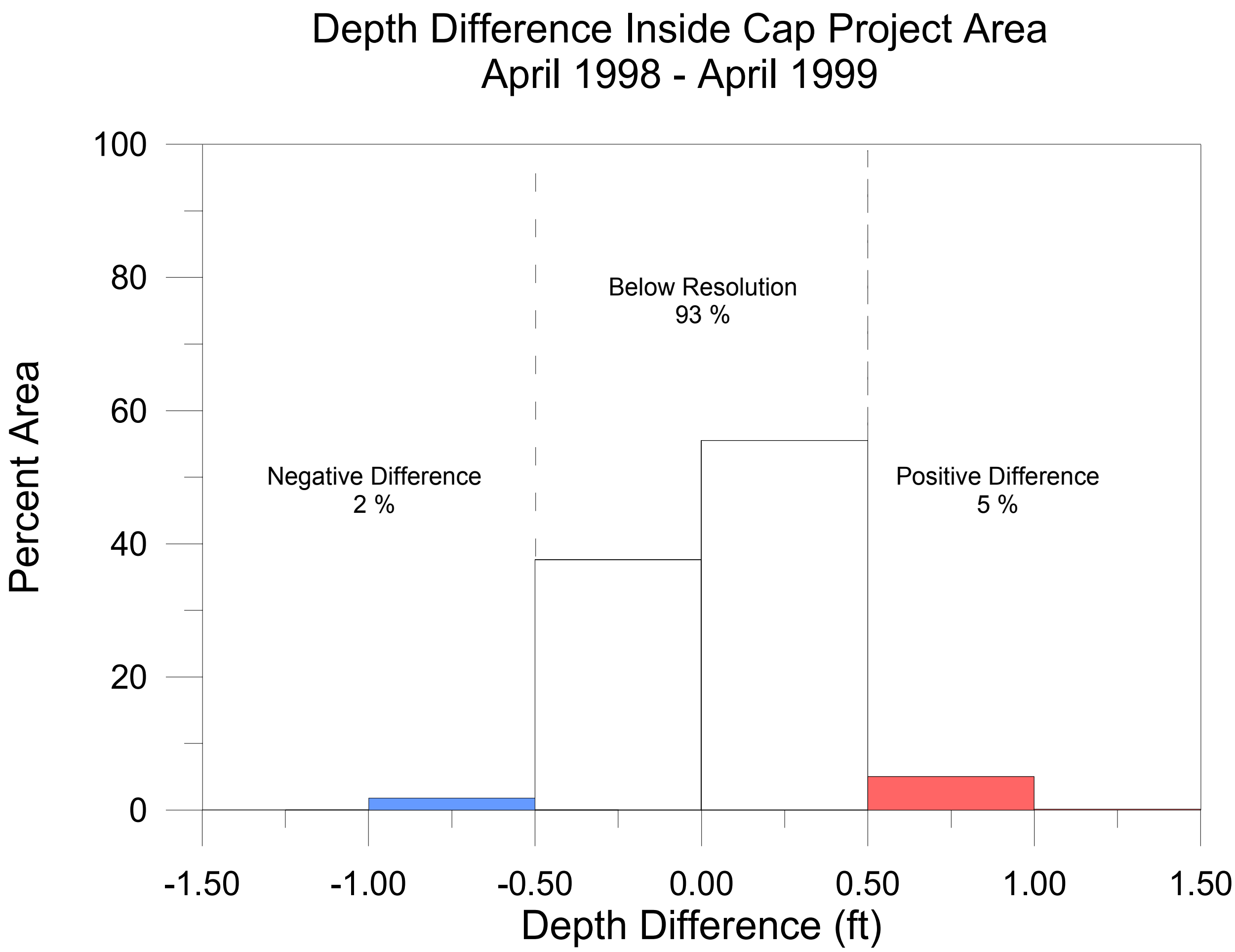


Figure 3-7. Histogram plot of the total negative and positive differences from the one-year postcap depth difference grid. The distribution is based on 1,477 25-m cells within the dredged material footprint.

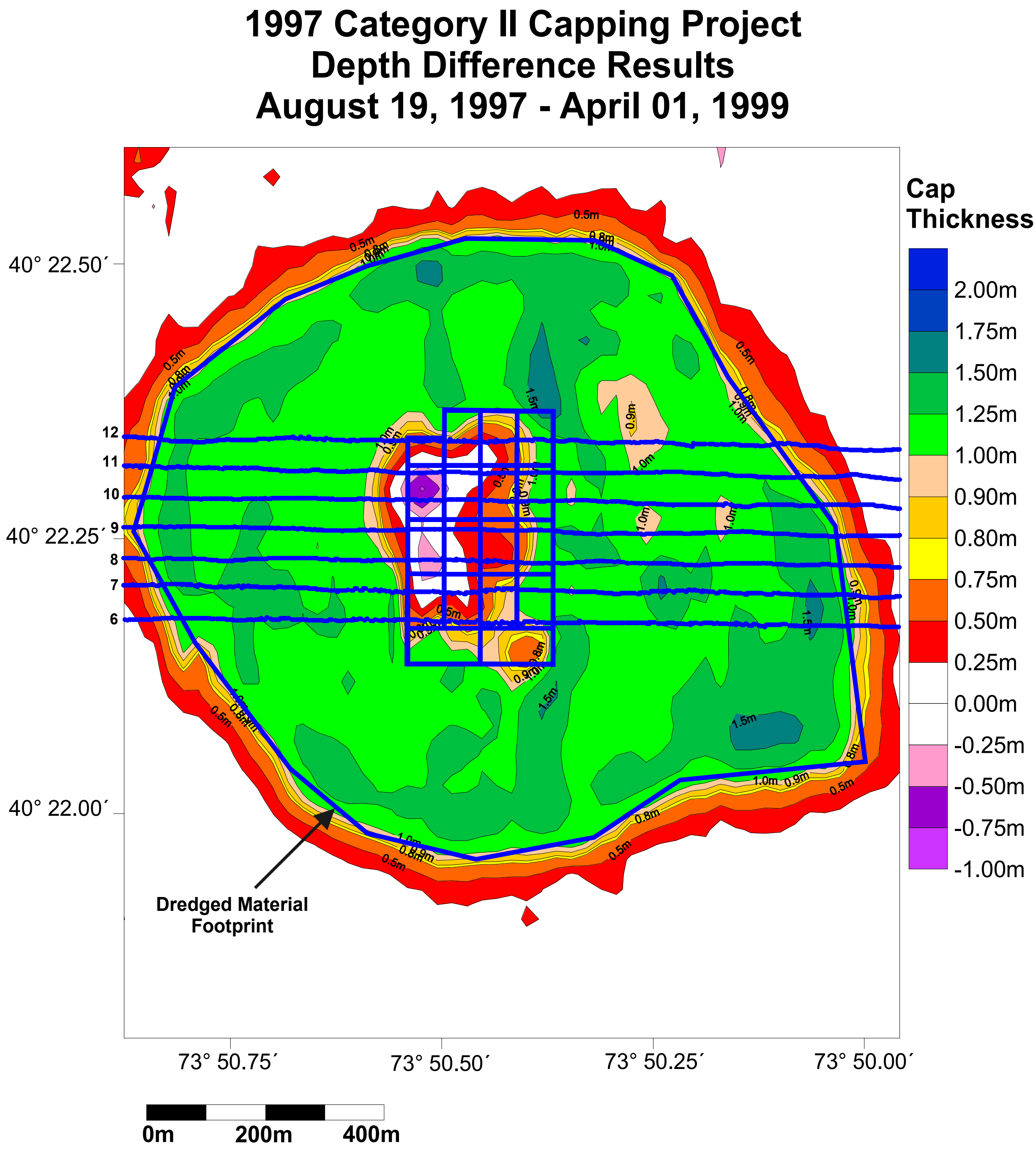


Figure 3-8. Track plot of seven east-west bathymetric crosslines surveyed across the 1997 Category II Project sand cap. The track lines are overlaid on the depth difference results between the August 1997 postdisposal and April 1999 one-year postcap surveys.

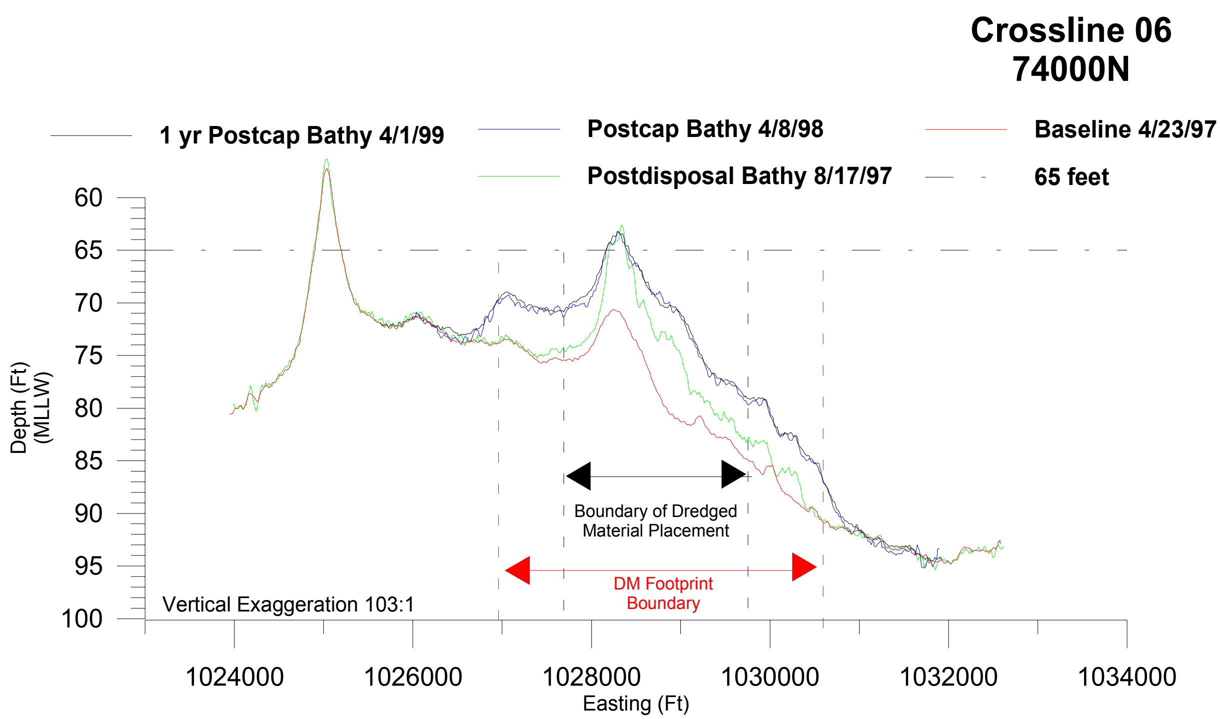


Figure 3-9. Time series bathymetric profile data from Crossline 6. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

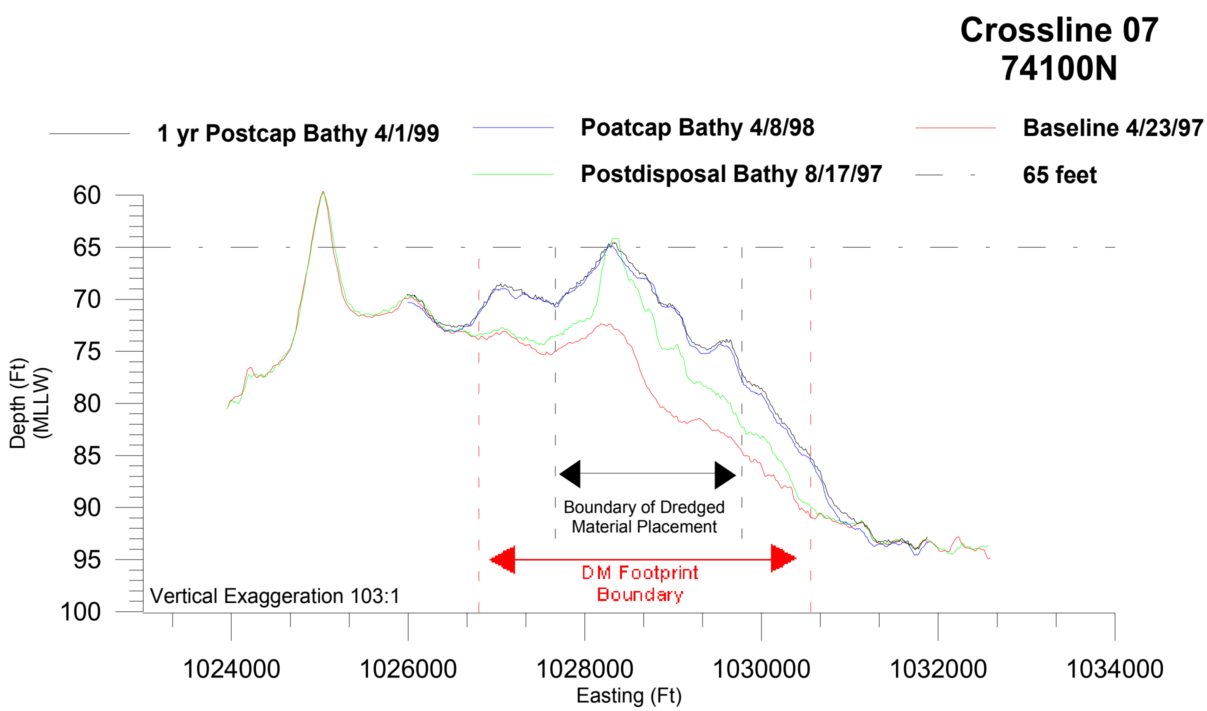


Figure 3-10. Time series bathymetric profile data from Crossline 7. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

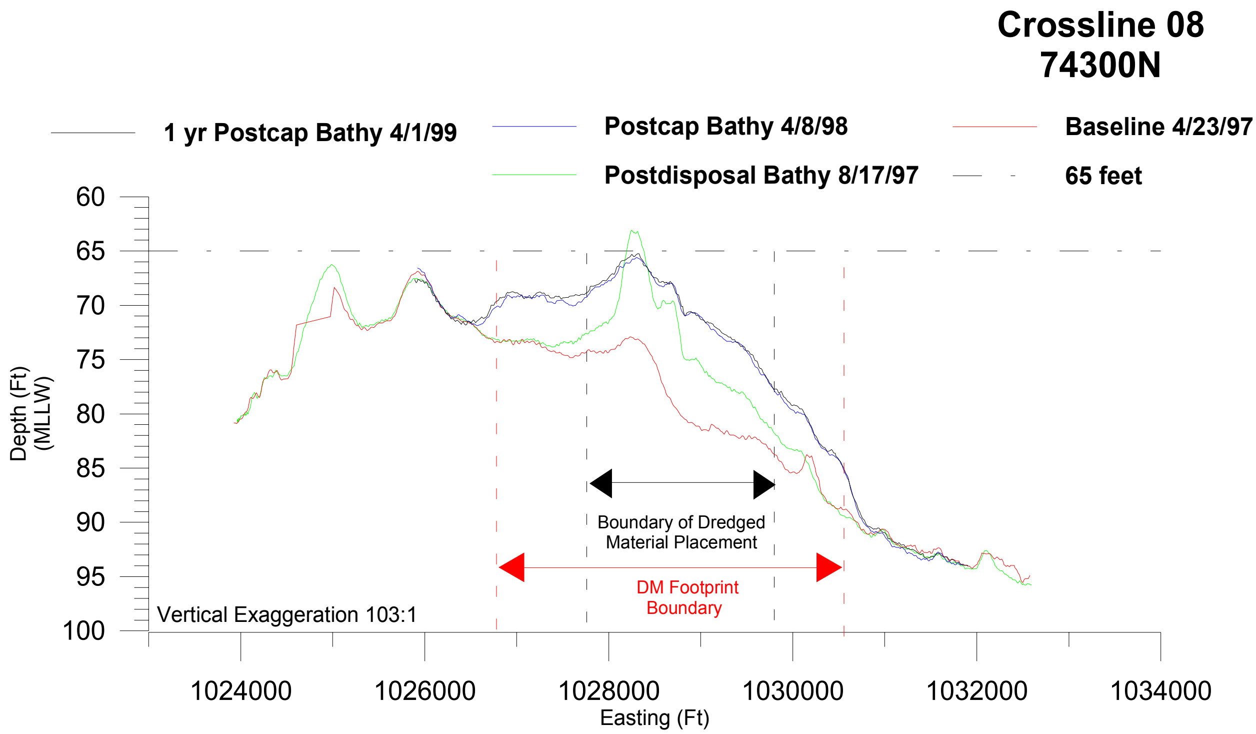


Figure 3-11. Time series bathymetric profile data from Crossline 8. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

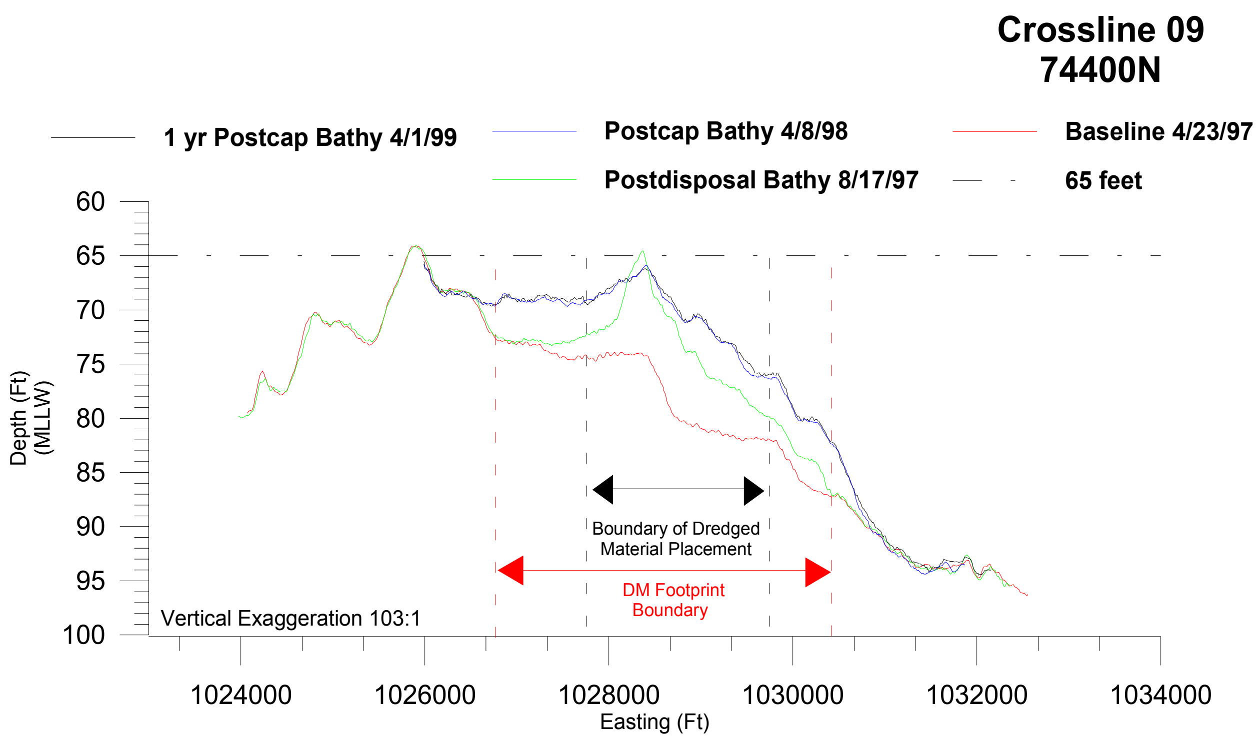


Figure 3-12. Time series bathymetric profile data from Crossline 9. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

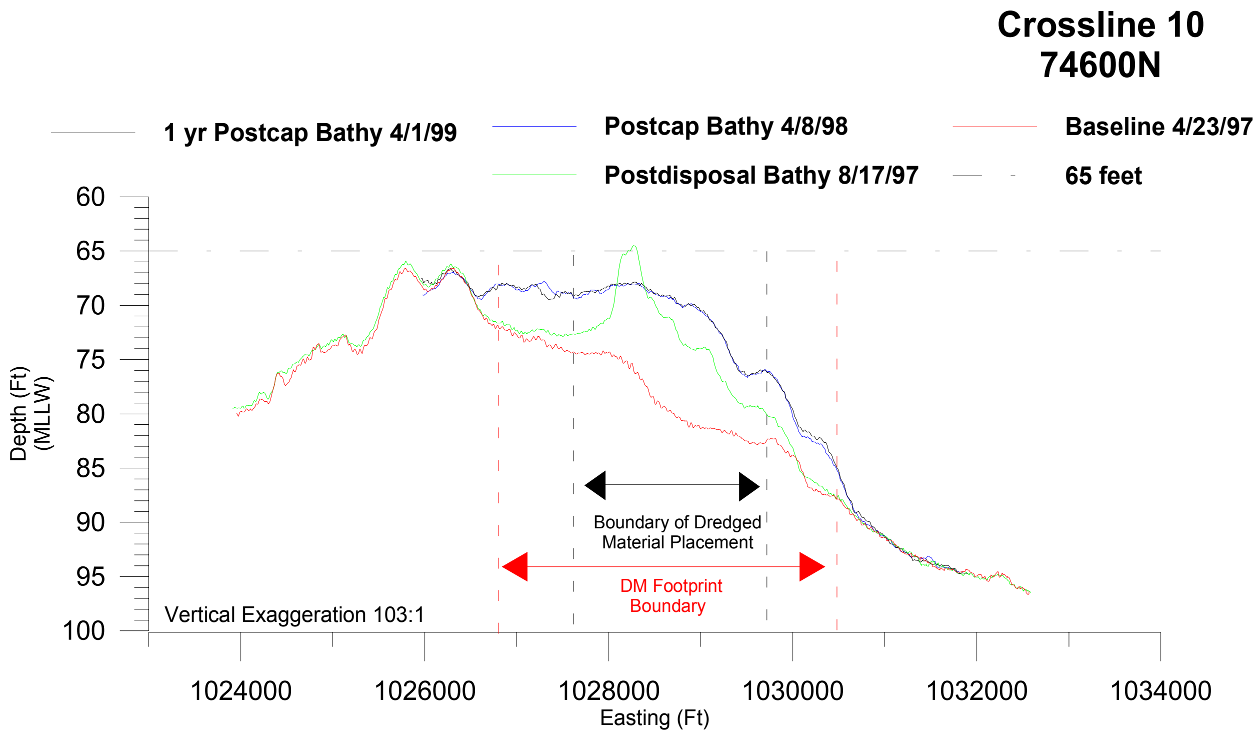


Figure 3-13. Time series bathymetric profile data from Crossline 10. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

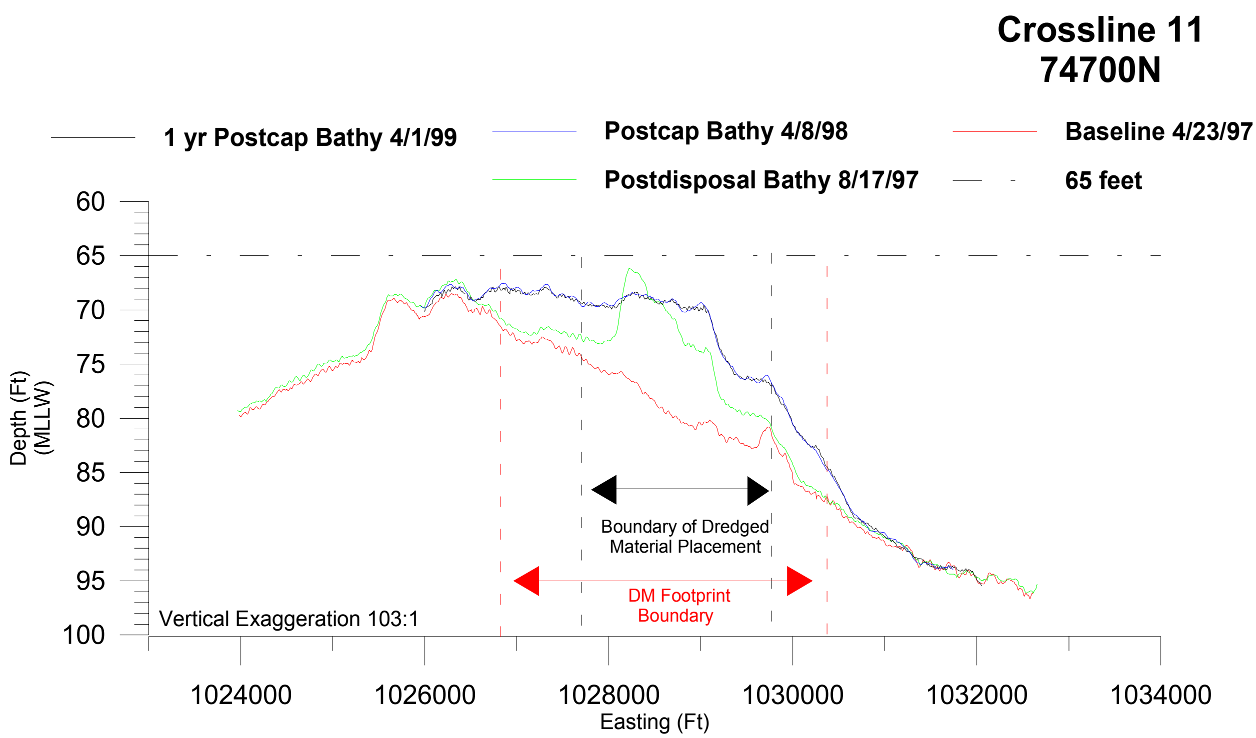


Figure 3-14. Time series bathymetric profile data from Crossline 11. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

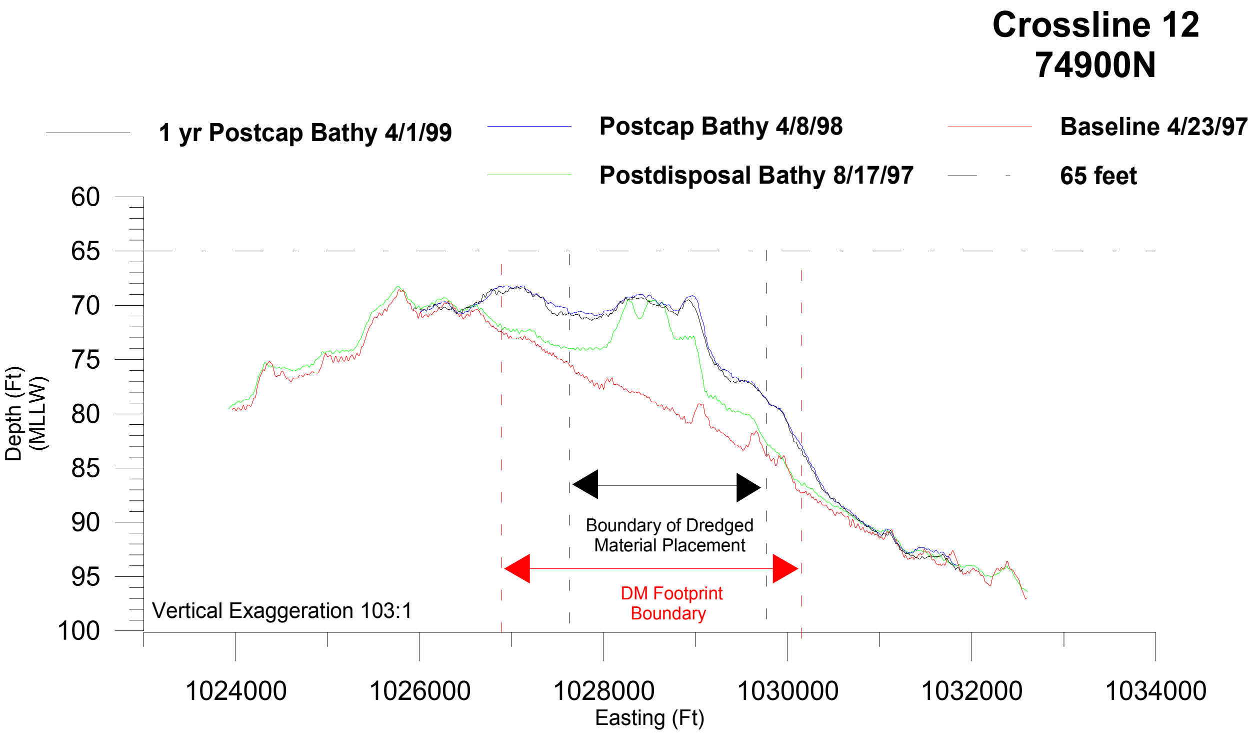


Figure 3-15. Time series bathymetric profile data from Crossline 12. Profile data from the baseline, postdisposal, postcap, and one-year postcap surveys are presented.

4.0 REMOTS® SURVEY RESULTS

A total of 221 REMOTS® sediment-profile images from the 90 project area stations and 20 reference area stations were analyzed for the April 1999 one-year postcap survey. The results of the REMOTS® image analyses are presented below. These data are also presented in tabular form in Appendix A.

4.1 REMOTS® Image Analysis

4.1.1 Horizontal Distribution of Sediment Grain Size

The one-year postcap bathymetric survey conducted in April 1999 revealed that cap thickness within the 1997 dredged material footprint polygon (i.e., capping boundary) was generally unchanged since the first postcap survey of 1998 (see Section 3.0). Analysis of the REMOTS® images from the April 1999 one-year postcap survey confirmed that surface sediments at the majority of stations within the capping boundary consisted of rippled, well-sorted, fine sand having a major modal size of 3-2 phi (Figures 4-1 and 4-2). This clean, fine sand is assumed to be the cap sand from Ambrose Channel placed systematically within the capping boundary over the period August 1997 to January 1998.

In most of the REMOTS® images acquired at stations on the sand cap, the sand extended from the surface to below the imaging depth of the REMOTS® camera prism (e.g., Figure 4-2). There was some minor variability in grain size major mode on the sand cap: while images at most stations showed fine sand (3-2 phi), there were some stations dominated by very fine sand (4-3 phi; Figure 4-1). This probably reflects natural variability in the cap material from Ambrose Channel.

The cap sand was generally well-sorted and had high albedo (i.e., a bright white color in sediment profile images, see Figure 4-2). This sand was similar in appearance to the sand used for capping of the 1993 Dioxin Capping Monitoring Project (SAIC 1995); this is not surprising as Ambrose Channel was the source of the sand in both cases. The sand at most stations exhibited ripples which were a few centimeters in height and both symmetric and asymmetric in profile (Figure 4-2). The widespread presence of ripples in both the first postcap and the one-year postcap survey results suggests that the sand comprising the surface of the cap is subject to some bed-load transport. Similar capillary ripples have been observed consistently on the surface of the 1993 Dioxin Capping Monitoring Project sand cap during each of three postcap REMOTS® surveys (SAIC 1995, 1997b and c).

Although the capping sands were “clean”, we noted a thin layer of flocculent mud/organic matter on the surface. This is interpreted as the product of detrital production (seston) from the overlying water column and/or fine-grained material resuspended from the ambient bottom. None of this floccular material appears to be in the process of incorporation into the rippled sand. It is likely, however, that this transient floccular material is being utilized as detrital food by Stage I species that have settled on the cap.

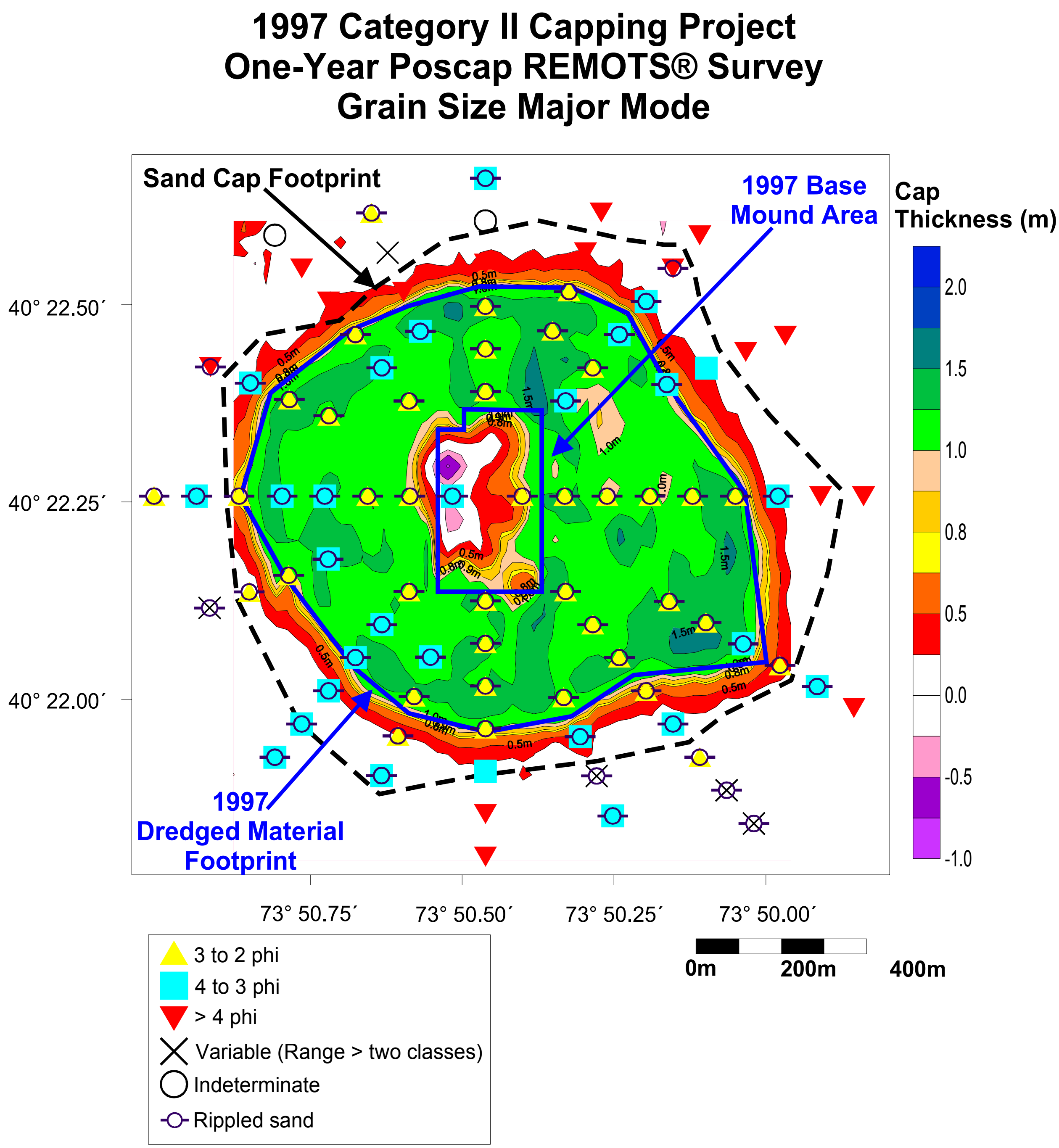


Figure 4-1. Grain size major mode at the radial transect stations, presented in relation to sand cap thickness as determined in the April 1999 postcap bathymetric survey. The broken black line denotes the footprint of the sand cap based on the REMOTS® grain size results.

Figure 4-2. REMOTS® image from Station SE-100 illustrating the clean, rippled, fine sand comprising the sand cap. Scale: image width = 15 cm.

The footprint of the sand cap, as defined by REMOTS®, covered a slightly more extensive area than that defined in the postcap high-resolution bathymetry survey (Figure 4-1). In general, the REMOTS® footprint extended roughly 50 to 200 meters beyond the footprint defined through high-resolution bathymetry (Figure 4-1). This is not surprising, since REMOTS® is able to detect depositional layers of sand on the flanks of the cap which are too thin (i.e., less than about 0.5 ft thick) to be detected using acoustic methods. In REMOTS® images obtained at several stations in flank regions near the outer edge of the sand cap (e.g., WSW-200, E-700, NE-300, NNE-200, SSE-100, ENE-0), the cap sand was visible as a thin surface layer overlying fine-grained, relic dredged material at depth (Figure 4-3). The REMOTS® images from three consecutive NE radial transect stations (NE-200, NE-300, and NE-400) serve to illustrate the transition in sediment type typically encountered at the outer edge of the sand cap (Figure 4-4).

Compared to the uniform distribution of clean, rippled, fine sand on the surface of the one year old cap, the area surrounding the sand cap showed greater variability in sediment grain size. Surface sediments ranging in size from <-1 phi (gravel) to >4 phi (silt-clay) were found in this area (Figure 4-5). In general, areas to the east and northeast of the sand cap were dominated by fine-grained sediments (>4 phi) representing relic dredged material (Figure 4-1 and 4-4c). Likewise, the outer two stations of the S radial transect (S-500 and S-600) were dominated by fine-grained, relic dredged material (Figure 4-1). The area to the north and northwest of the sand cap was characterized by sediments having variable grain size; this is generally an area of hard bottom characterized by a mixture of relic dredged material, sand, pebbles and cobbles (Figure 4-6). The rippled, fine sand found at stations to the west and southwest of the 1997 sand cap is presumed to be cap material from the 1993 Dioxin Capping Monitoring Project. The fine sand and cobbles on the sloping bottom southeast of the sand cap are presumed to be naturally occurring combined with relic dredged material sediment types in this location (Figure 4-1).

The grain-size frequency distribution illustrates how the majority of stations were dominated by sediments having a major mode of 3-2 or 4-3 phi (Figure 4-5). This is not surprising because most of the stations were located on the sand cap, which was comprised predominantly of fine and very fine sand. The North Reference Area was dominated by fine sand (3-2 phi), (Figures 4-7 and 4-8), with the images from all stations showing sand ripples to be present. There was no clear spatial pattern to the distribution of the fine versus the medium sand within the North Reference Area. A medium sand fraction (2-1 phi) was found in replicates at Stations NREF-02, NREF-06 and NREF-16, while the remaining stations had moderately- to well-sorted fine sand.

Rippled, fine sand (3-2 phi) was the dominant sediment type at the South Reference Area (Figure 4-9). The sand tended to be well-sorted and was distributed uniformly throughout the area, except at Stations SREF-13, SREF-14, and SREF-15 where very fine sand (4-3 phi) was the dominant grain size major mode. Layered stratigraphy in which fine sand covered black, fine-grained sediment at depth was observed at station SREF-17; the same sediment layering has been observed at this station in several past REMOTS® surveys (Figure 4-10; SAIC 1997b, c and e). The underlying black sediment is presumed to be relic dredged material resulting from historic disposal outside the MDS boundaries. The frequency distribution of grain size major mode values reflects the dominance of fine sand (3-2 phi) at both the North Reference Area and the South Reference Area (Figure 4-8).

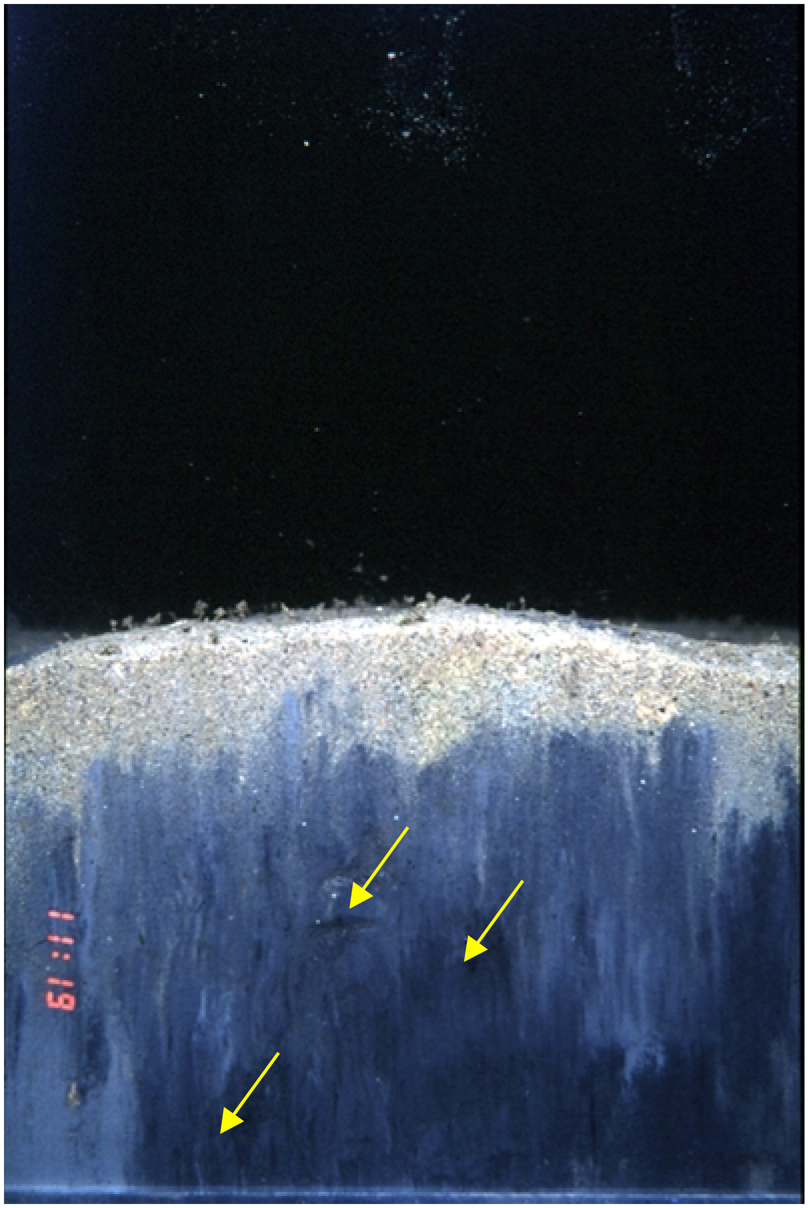
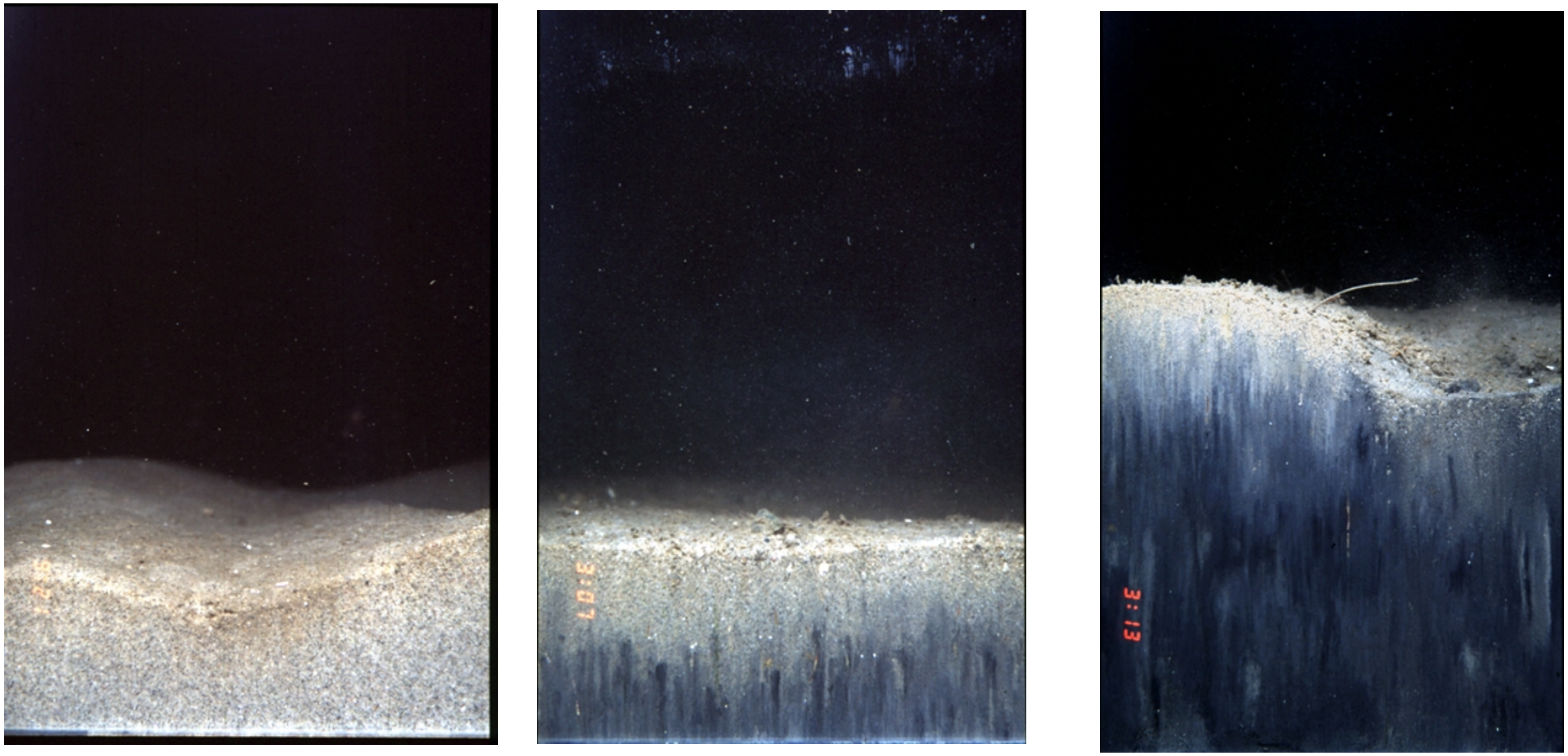


Figure 4-3. A thin surface layer of clean cap sand overlies black, fine-grained, relic dredged material in this REMOTS® image from Station SSE-200. Note the apparent RPD and Stage I species at the interface and Stage III feeding voids at depth (arrows). Scale: image width = 15 cm.



A B C

Figure 4-4. REMOTS® images from three consecutive stations on the NE transect, illustrating a transition in sediment type at the outer edge of the sand cap. A) clean rippled cap sand at Station NE-200, B) a thin surface layer of cap sand over black relic dredged material at Station NE-300, and C) fine-grained relic dredged material with a well developed redox layer and no overlying cap material at Station NE-400. Scale: image width = 15 cm.

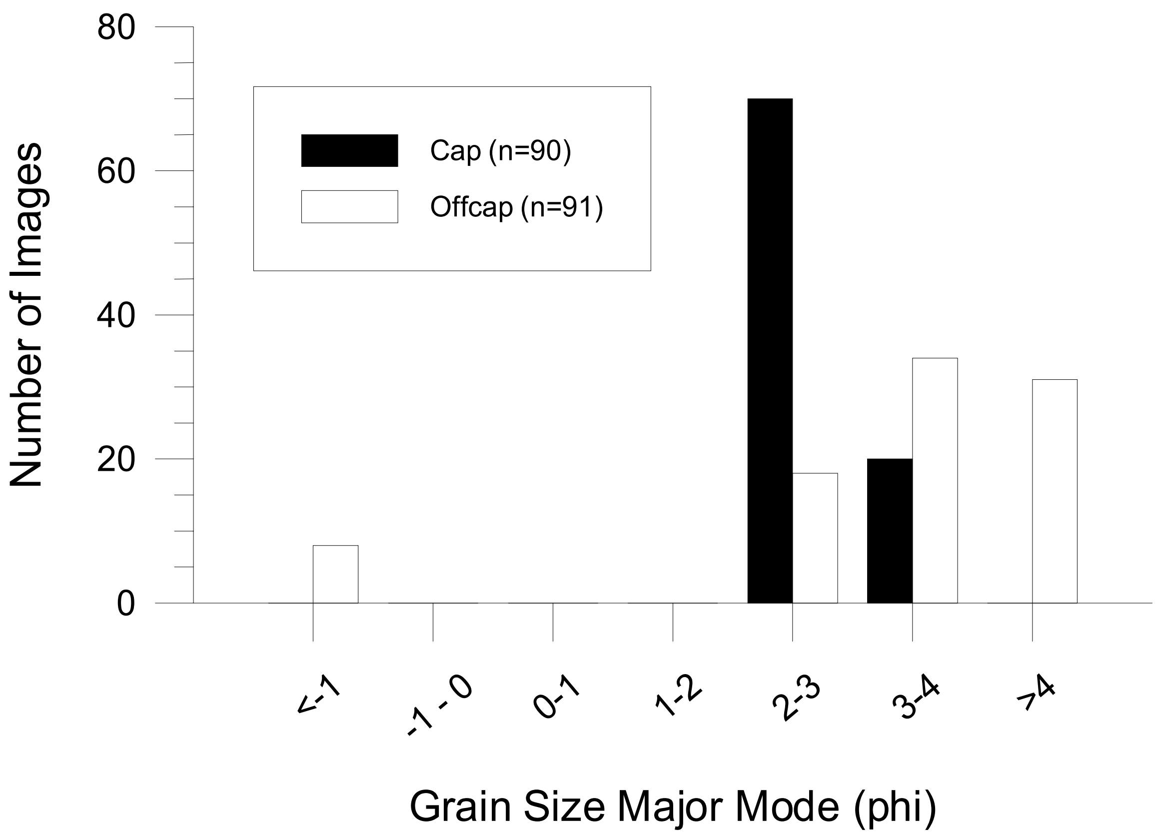


Figure 4-5. Frequency distribution of grain size major mode for REMOTS® images obtained on and around the 1997 Category II capped project mound.

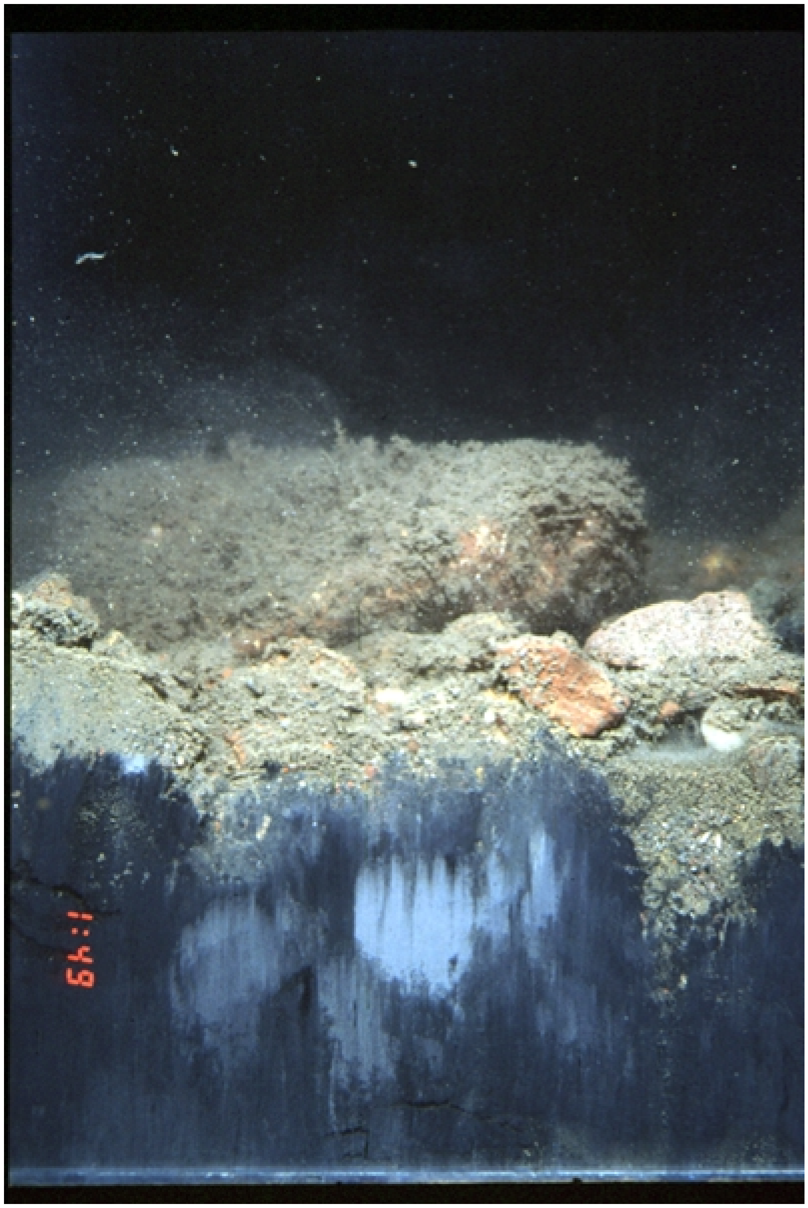


Figure 4-6. REMOTS® image from Station NW-400 illustrating the black, fine-grained, relic dredged material with rocks and brick fragments on the surface. This "chaotic fabric" is typical of dredged material. Scale: image width = 15 cm.

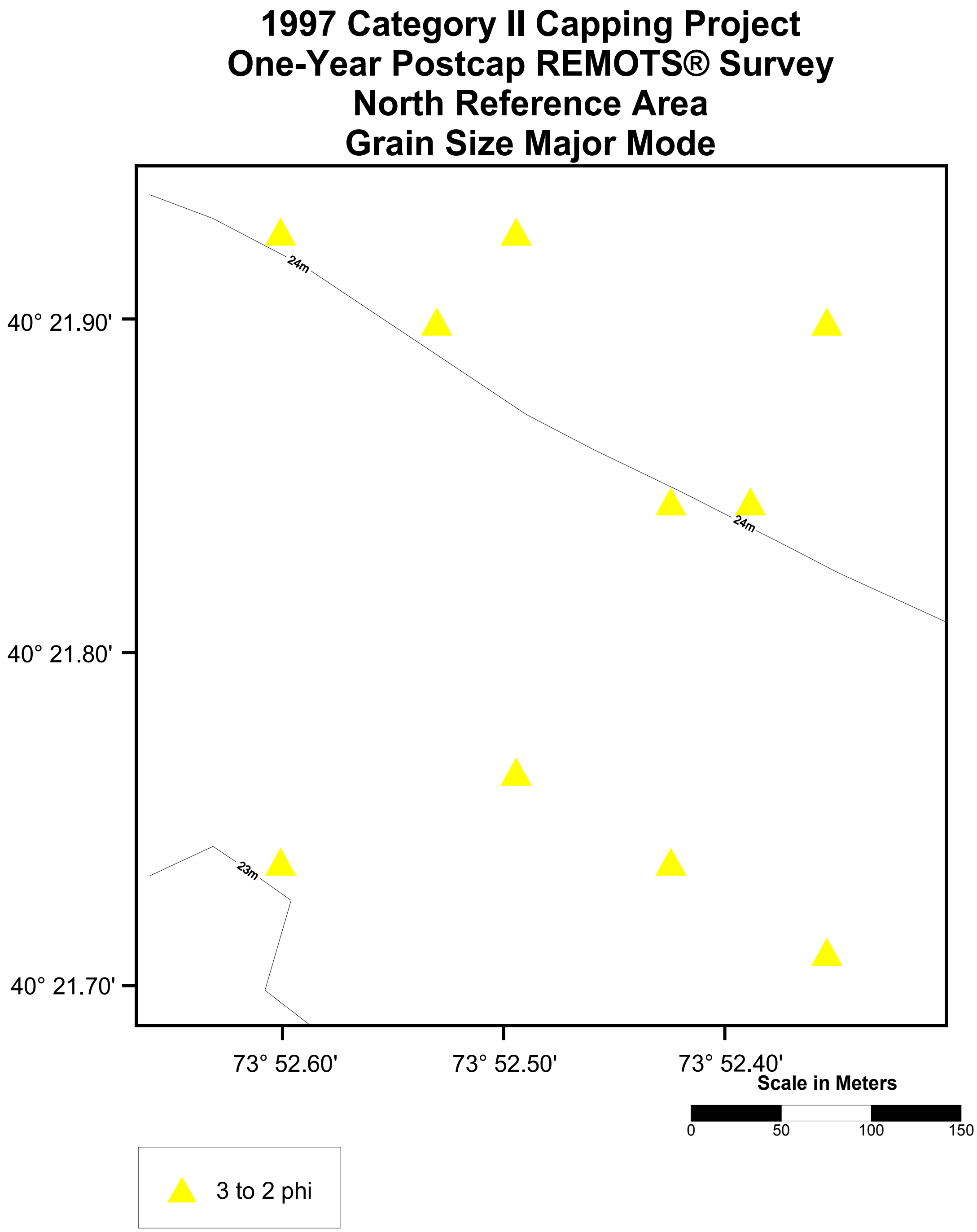


Figure 4-7. Grain size major mode at North Reference Area stations as determined from analysis of REMOTS® images.

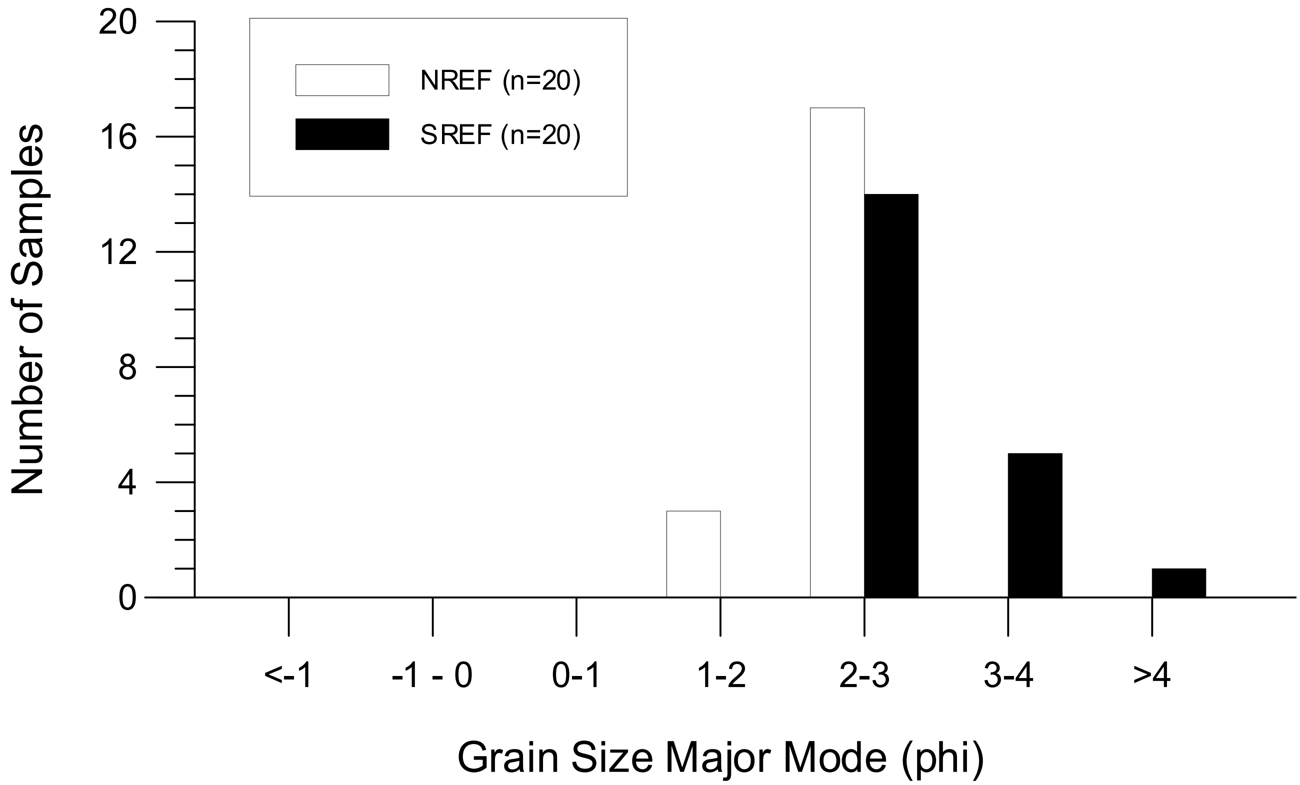


Figure 4-8. Frequency distribution of grain size major mode for REMOTS® images obtained at the North and South Reference Areas.

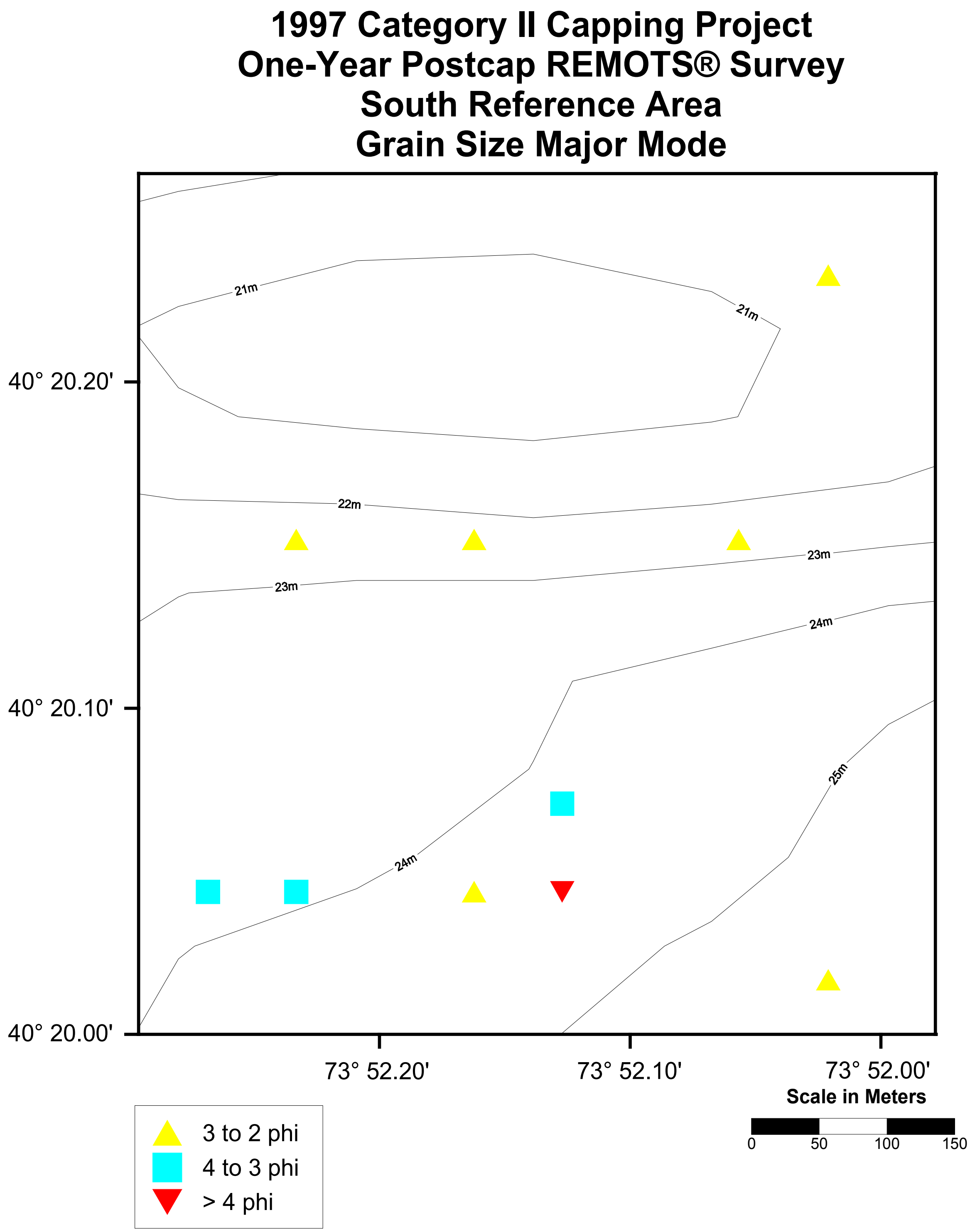


Figure 4-9. Grain size major mode at South Reference Area stations as determined from analysis of REMOTS® images.

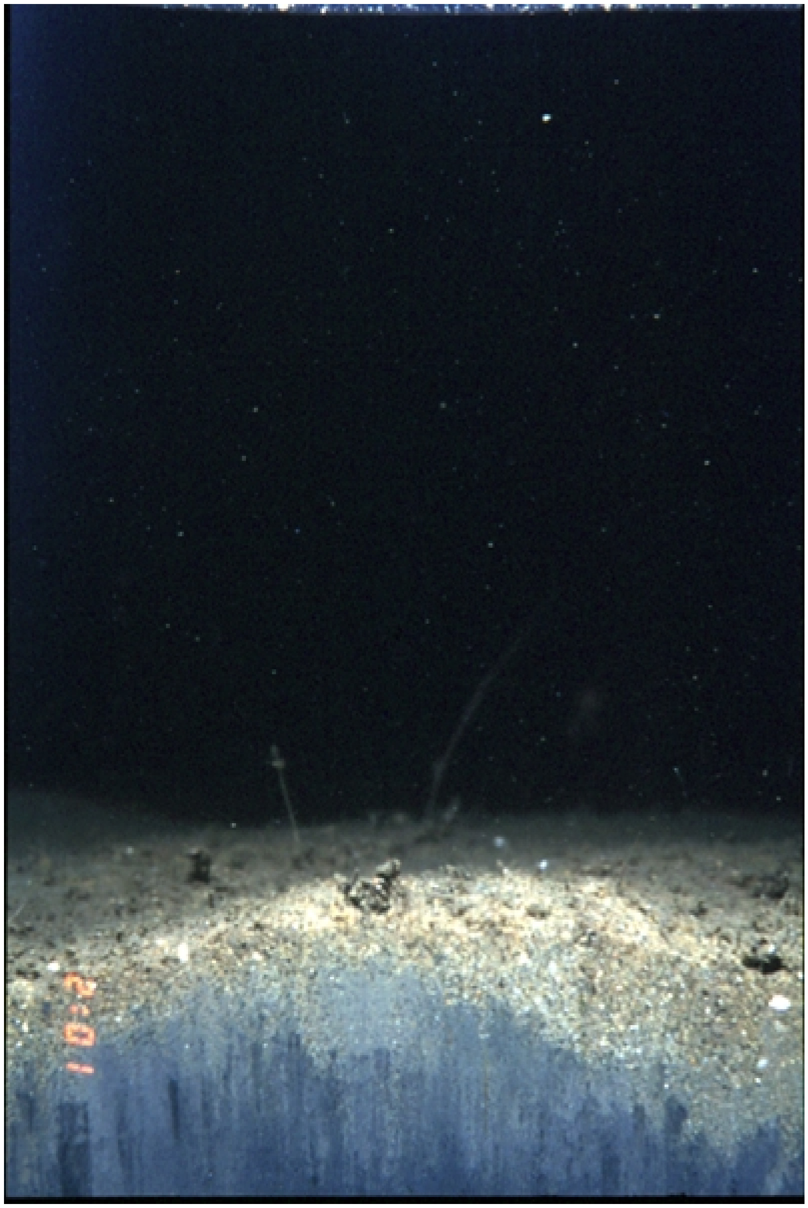


Figure 4-10. Layered stratigraphy of fine sand over black, fine-grained sediment at Station SREF 17. Scale: image width = 15 cm.

4.1.2 Dredged Material Distribution

In REMOTS® images, newly deposited dredged material typically is identified based on the following characteristics: it is fine-grained (i.e., silt-clay), has low optical reflectance (i.e., dark-colored), and often has distinct color or textural properties (e.g., chaotic sedimentary fabric, poor sorting, over-consolidation, or layered stratigraphy). Physical boundary roughness on, and near the mound apex, also tends to be high relative to flank deposits. In the April 1999 one-year postcap REMOTS® survey, there was sand deeper than camera penetration at all cap stations except one replicate at Station ESE-100, which had cap sand over dredged material (Figure 4-11 and 4-12). The bathymetry results show 1.5 m of sand cap in this area. Since the dredged material was seen in only one of three replicate images obtained at Station ESE-100, it is deemed as a small isolated patch. It is possible that during cap placement a small portion of fine-grained material became entrained within the sand or it could have been material attached to the barge from a previous operation and was released with the sand cap material. With this exception, the sand layer, representing the surface of the cap, was sufficiently thick that no underlying dredged material was observed in any of the replicate REMOTS® images (Figure 4-2).

A number of stations outside the perimeter of the capped project mound had dredged material present (Figure 4-11). In particular, dredged material was found in areas to the north, northeast and east of the capped project mound, as well as at three stations on the outer end of the S station transect. The dredged material typically consisted of low-reflectance, fine-grained sediment (silt-clay or very fine sand) which extended from the seabed surface to below the camera's imaging depth (Figure 4-13). At some of the stations (indicated in Figure 4-11), a distinct sand-over-dredged material stratigraphy was present (Figures 4-3 and 4-4b).

The dredged material observed at the stations indicated in Figure 4-11 is presumed to be relic material, the result of past disposal at the MDS which had occurred well in advance of the 1997 Category II Capping Project. This is based on the characteristic black color of this material (e.g., Figures 4-3, 4-4c and 4-13) and the fact that it was found outside the footprint of the 1997 project material. Furthermore, this relic dredged material had been observed in the areas to the northeast and south of the 1997 Base Mound Area in the baseline REMOTS® survey conducted prior to the disposal operations for the 1997 Category II Capping Project (SAIC 1997d).

Dredged material was not observed in any of the replicate REMOTS® images obtained in the North Reference Area. At the South Reference Area, station SREF-17 exhibited sand-over-dredged material stratigraphy similar to that observed at some of the disposal site stations (Figure 4-10). Station SREF-17 and nearby stations are located in a topographic depression (trough) near the southern border of the South Reference Area; relic dredged material has been observed in this area in numerous previous REMOTS® surveys (SAIC 1995, 1997b, c, and d).

4.1.3 Boundary Roughness

Measurements of small-scale surface boundary roughness are limited by the size of the REMOTS® camera window (15 × 20 cm). When small-scale surface features predominate (e.g., sand ripples

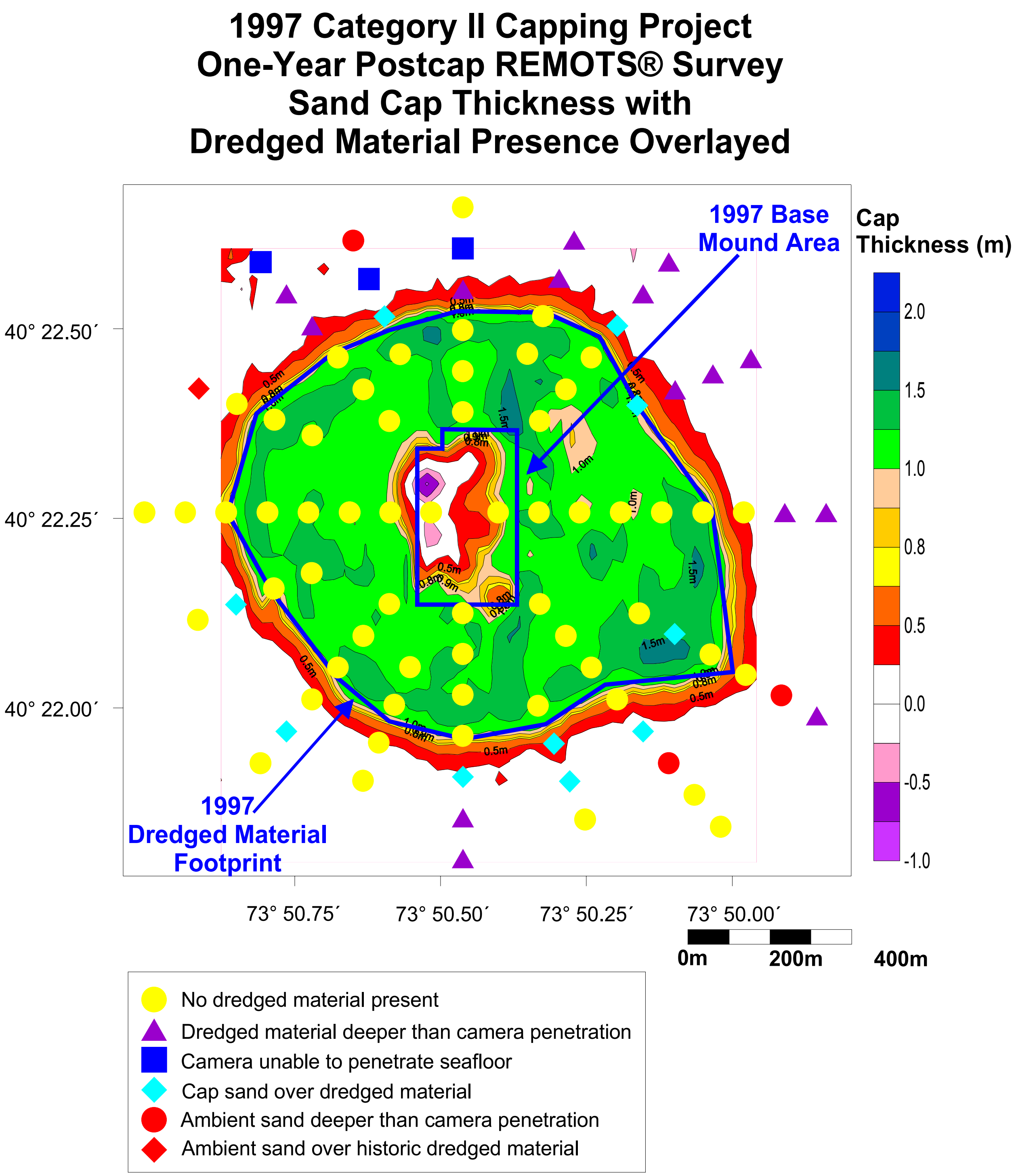


Figure 4-11. Dredged material distribution in the survey area as determined from REMOTS® images.

Figure 4-12. REMOTS® image from Station ESE-100 showing a thin layer of black, fine-grained material below fine cap sand. Scale: image width = 15 cm.

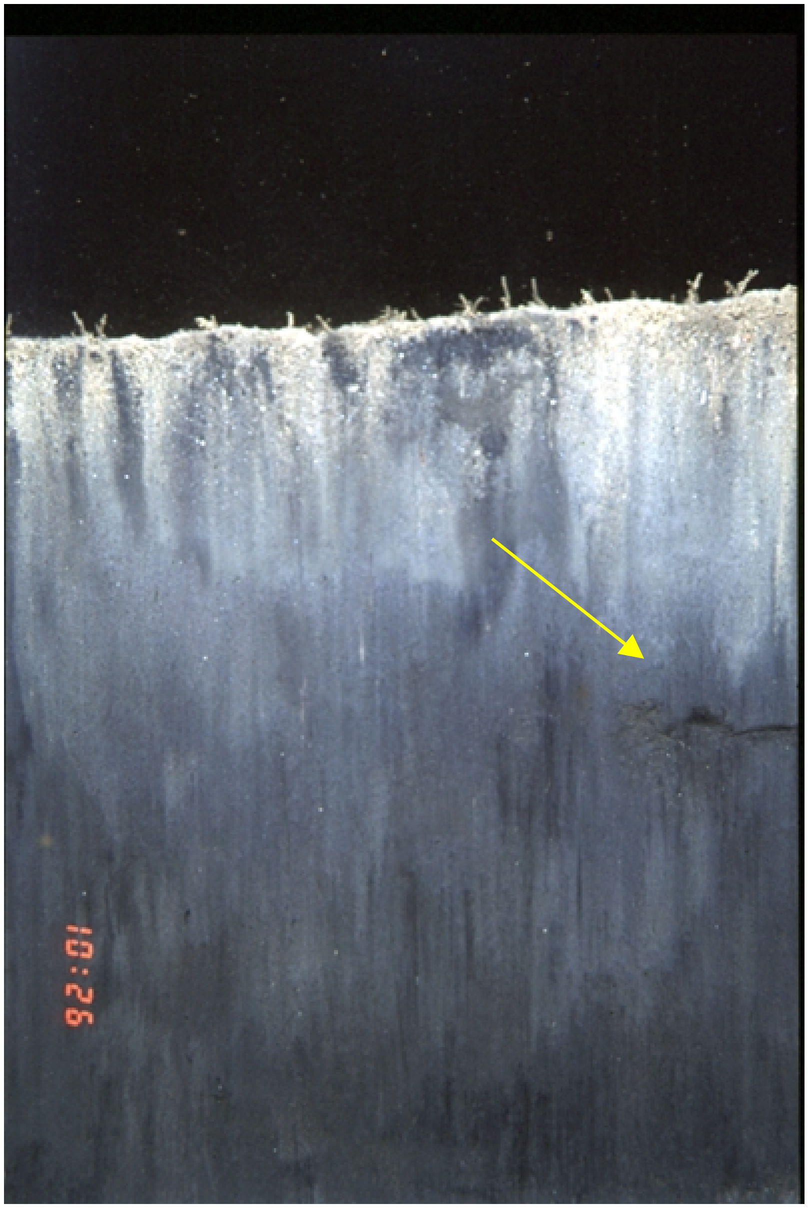


Figure 4-13. REMOTS® image from Station ENE-300 showing fine-grained, relic dredged material extending from the sediment surface to below the camera's imaging depth. Note Stage I worm tubes at surface and Stage III feeding void at depth (arrow). Scale: image width = 15 cm.

with amplitudes less than the width of the camera window), the camera can provide an accurate measure of boundary roughness. However, the camera cannot provide an accurate measurement of boundary roughness when large-scale features predominate (e.g., sand ripples with amplitudes exceeding the width of the REMOTS® camera window), making it difficult to provide a complete assessment of boundary roughness across most surveyed areas. Therefore, boundary roughness measurements must be interpreted with caution.

Figure 4-14 shows the spatial distribution of small-scale boundary roughness in the project area; the mapped values are averages for the replicate images obtained at each station. Because these measurements are for small-scale features (e.g., sand ripples with amplitudes less than the width of the camera window), they are considered to be accurate. It is not surprising that due to the ubiquitous presence of sand ripples, the capped area had higher small-scale boundary roughness than surrounding areas, where many of the stations were characterized by fine-grained historic dredged material having little or no small-scale surface relief. The majority of boundary roughness values in the capped area were in the 1.5-3.0 cm range, while most of the values measured in adjacent areas ranged from 0 to 1.5 cm (Figure 4-15). An anomolously high boundary roughness value of 4.69 cm at station NW-400 was related to the presence of a large sand ripple in one of the replicate images from this station. Overall, the mean boundary roughness value for all radial transect stations was 1.37 cm, with measured values ranging from 0 to 4.69 cm (Figure 4-15).

There was a wide range of boundary roughness values for the replicate images obtained in the North Reference Area, while all of the values in the South Reference Area were less than 2.0 cm, with equal numbers in the 1.0 to 1.5 and 1.5 to 2.0 cm size classes (Figure 4-16). The North Reference Area was dominated by coarser-grained sediments which would be expected to form larger amplitude ripples compared with the fine sand found at the South Reference Area and within the project area.

4.1.4 Camera Prism Penetration Depth

The depth of penetration of the REMOTS® camera prism can be used to map gradients in the bearing strength (hardness) of the sediment. This hardness parameter is useful for distinguishing between a relatively thick (>20 cm) layer of sand cap material or soft bottom related to the presence of thin caps or underlying silt/clay. Freshly deposited sediments or older, highly bioturbated sediments tend to be soft; while compacted sands are hard and resist camera prism penetration. During the one-year postcap survey, weight was added to, or removed from the REMOTS® camera frame, to optimize penetration in the diverse types of sediment encountered across the surveyed areas. Therefore, it is not possible to use camera prism penetration depth as a direct comparative measure of sediment bearing strength or density among different stations. Nevertheless, some broad qualitative comparisons of average prism penetration among stations are possible.

As might be expected, the deepest prism penetration (in the range of 10 to 20 cm) was found at stations with uncapped, bioturbated, relic dredged material on the NNE, NE, ENE and S transects (Figure 4-17). Intermediate penetration values (5 to 10 cm) were found at stations throughout

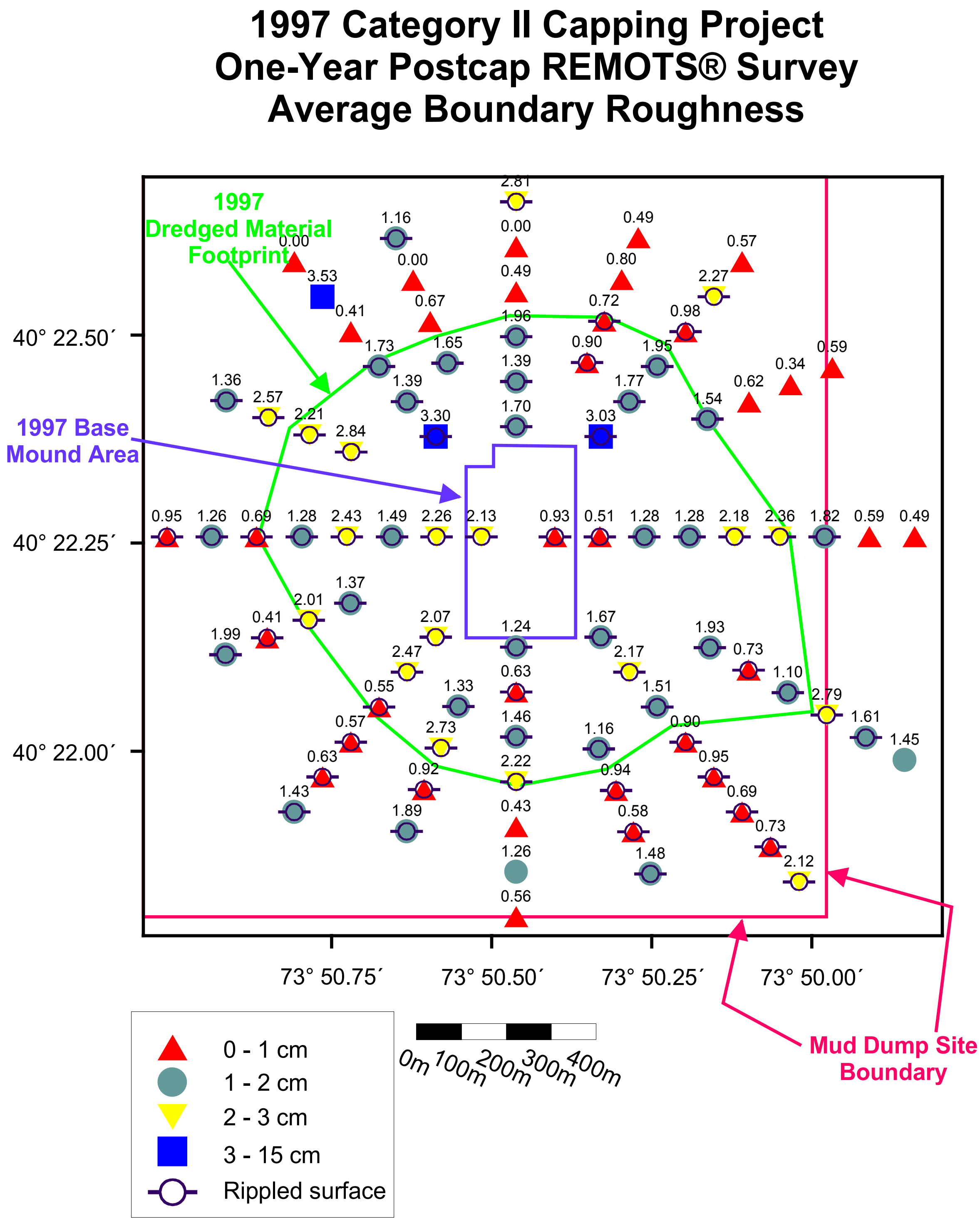


Figure 4-14. Average small-scale boundary roughness at the radial transect stations as determined from REMOTS® analysis.

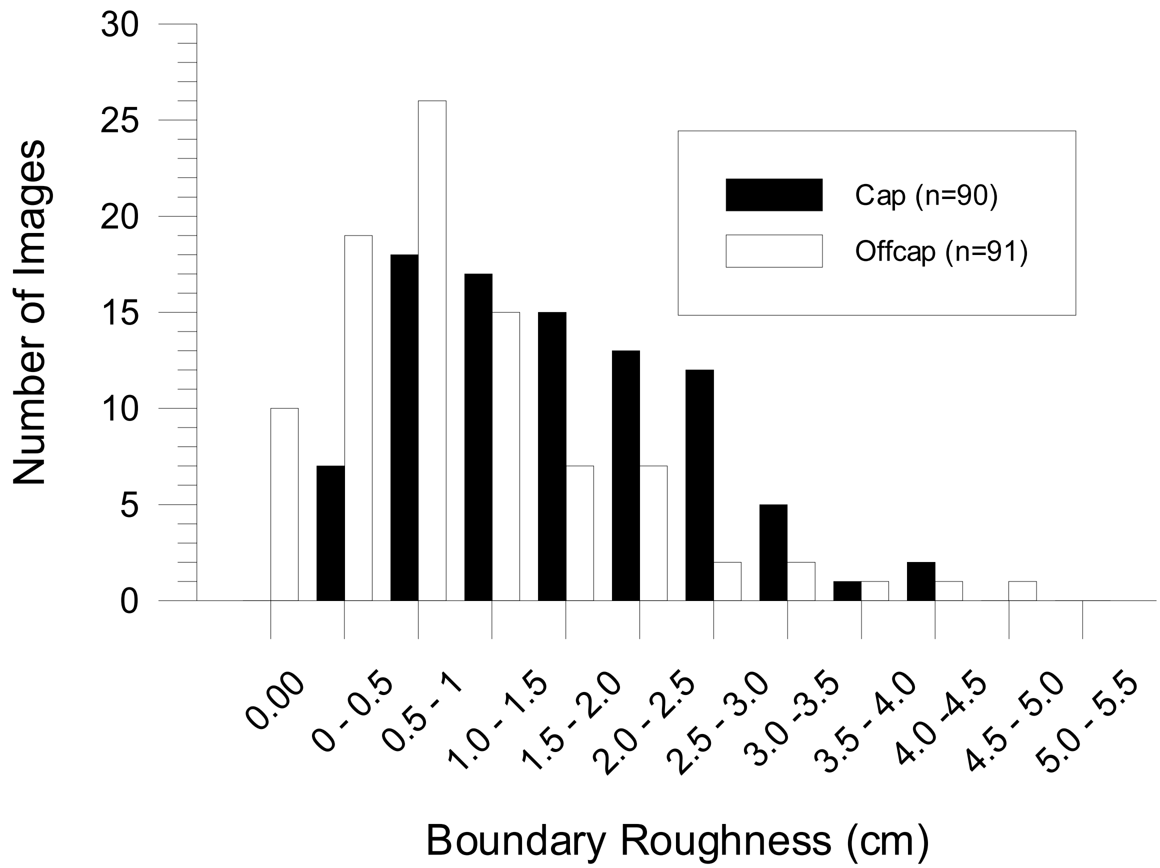


Figure 4-15. Frequency distribution of boundary roughness values (cm) for all replicate REMOTS® images obtained at the radial transect stations.

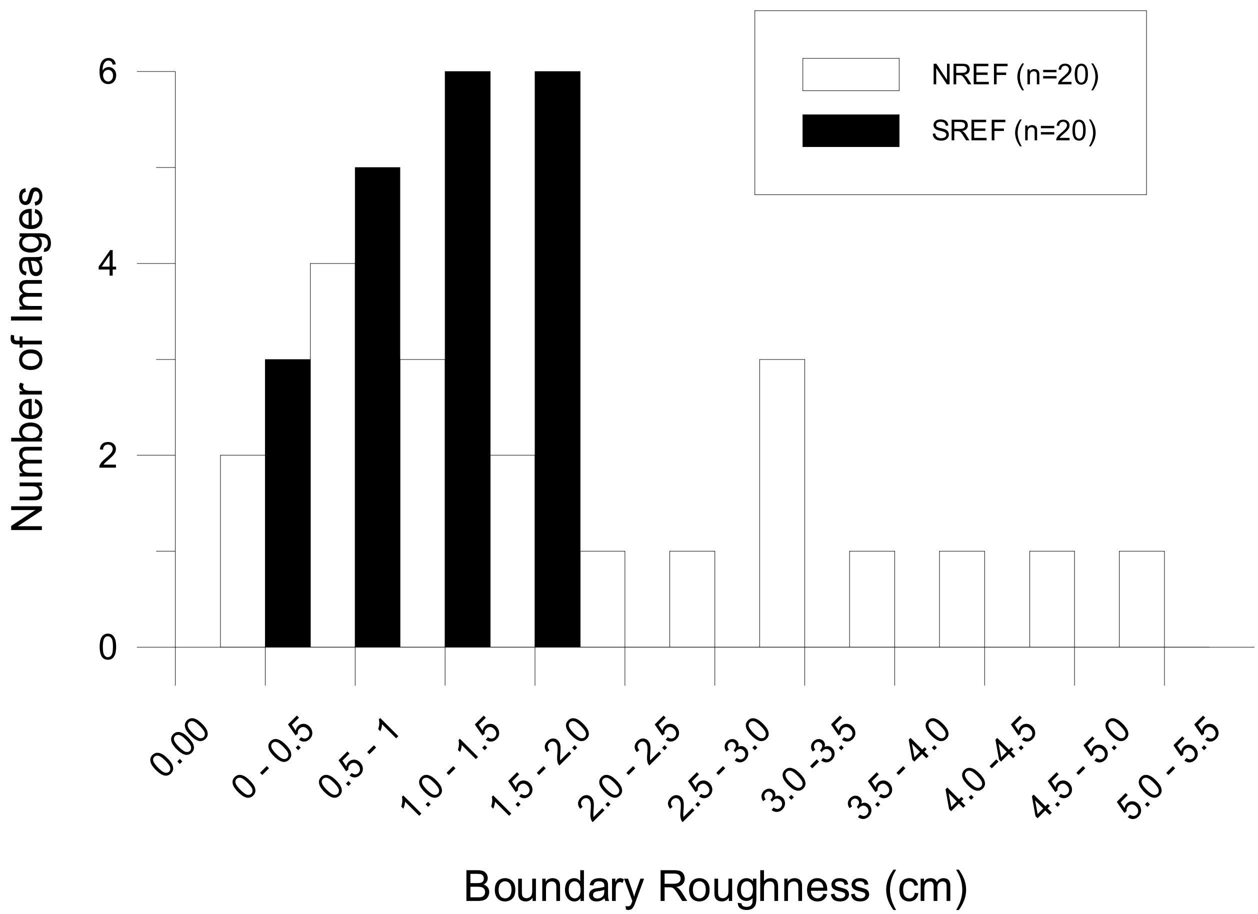


Figure 4-16. Frequency distribution of boundary roughness values (cm) for all replicate REMOTS® images obtained in the North and South Reference Areas.

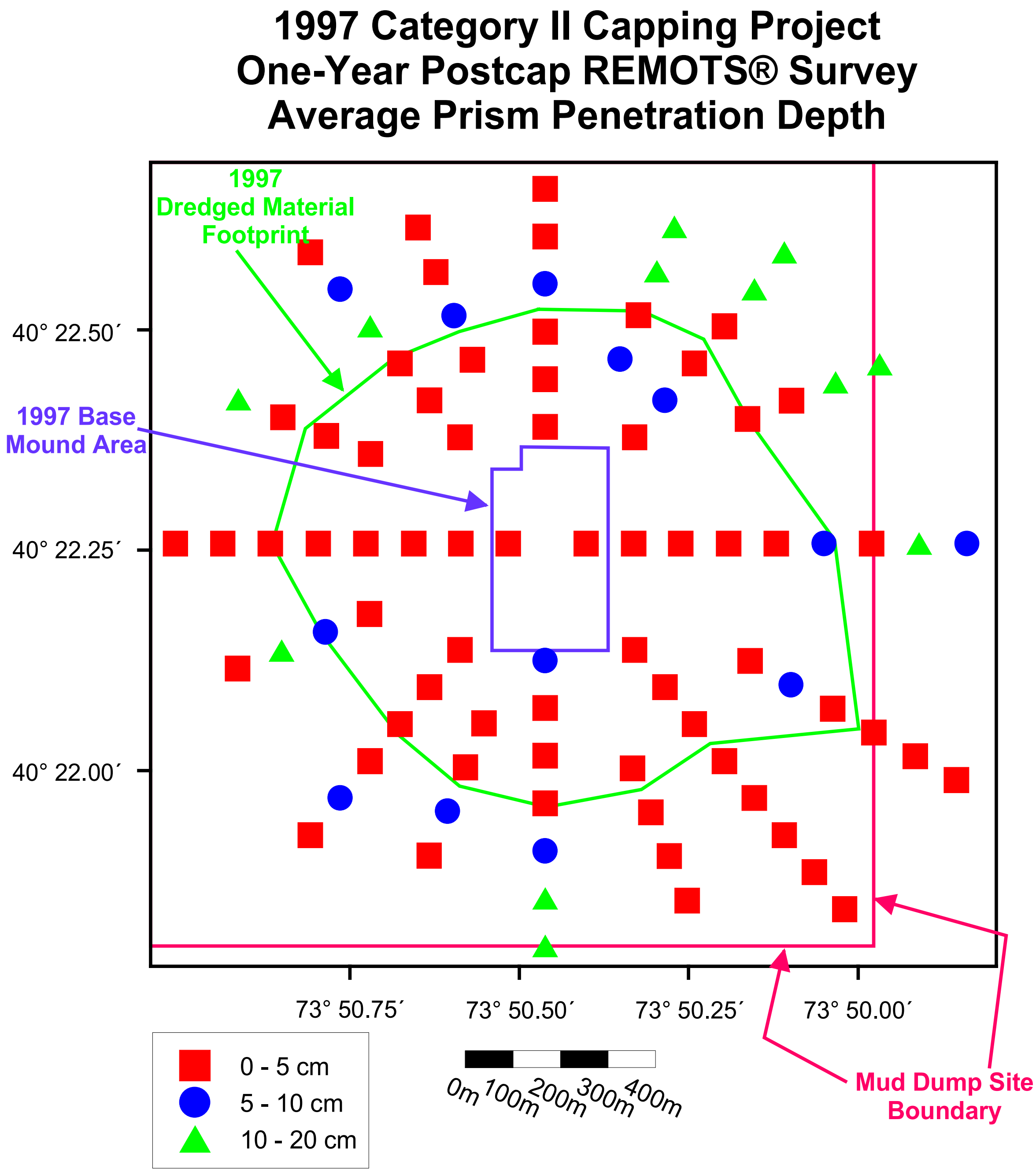


Figure 4-17. Average prism penetration depths at the radial transect stations.

the area (Figure 4-17). Most of the stations on the sand cap had relatively low prism penetration (0 to 5 cm), indicating that a relatively dense and compact layer of sand was present. The relatively narrow range of values at the sand cap stations (0 to 8 cm, with the majority of values falling between 3 and 5 cm) suggests spatial uniformity in the geotechnical properties of the sand cap (Figure 4-18).

Penetration depths at the North and South Reference Areas generally ranged between 1 and 10 cm (Figure 4-19). These values are consistent with those obtained on the rippled fine sand comprising the sand cap. No other consistent patterns or gradients in penetration depth were apparent within the sandy sediments of the North and South Reference Areas.

4.1.5 Infaunal Successional Stage

Due to the widespread presence of sand, especially on the sand cap, the penetration of the REMOTS® camera prism was limited to less than about 5 cm at a significant number of the radial transect stations. Because of this relatively shallow penetration, it was not possible to determine with certainty whether or not deeper dwelling organisms (e.g., Stage III infauna) were present. However, the successional Stage I was seen at the majority of the radial transect stations (Figure 4-20).

Stage I, in the form of polychaete tubes at the sediment surface, was found at 74 of the 90 (82%) radial transect stations (Figure 4-20 and 4-21). This included all but one of the stations located on the sand cap. The Stage I tubes were relatively smooth and occurred either singly or in small groups (Figure 4-22).

Stage I to II, Stage I on III and Stage II on III were found exclusively at radial transect stations having organic-rich, fine-grained dredged material. This included two stations on the NW transect, and the outer-most stations of ENE, E, and ESE transects as well as the next to outer-most stations of the SSE and S transects (Figures 4-13 and 4-20). The three outer-most stations on the NE transect were given a Stage I going to Stage II designation due to the presence of the shallow-dwelling, infaunal bivalve *Nucula* sp. at these stations (Figure 4-20 and Figure 4-23). Station ENE 200 was given the Stage II on Stage III designation because *Nucula* sp. were seen in sediment above feeding voids indicative of head-down orientation feeding Stage III taxa (Figure 4-24).

The successional stage at some (7 of 20) of the North Reference Area station replicates could not be determined adequately due to low prism penetration in the rippled fine to medium sands (Figure 4-25). At the South Reference Area, one replicate out of 20 was given an indeterminate successional stage designation. All of the other stations at the North and South Reference Areas were given a Stage I designation, reflecting the ability of Stage I polychaetes to maintain populations on the physically unstable rippled sands in these areas.

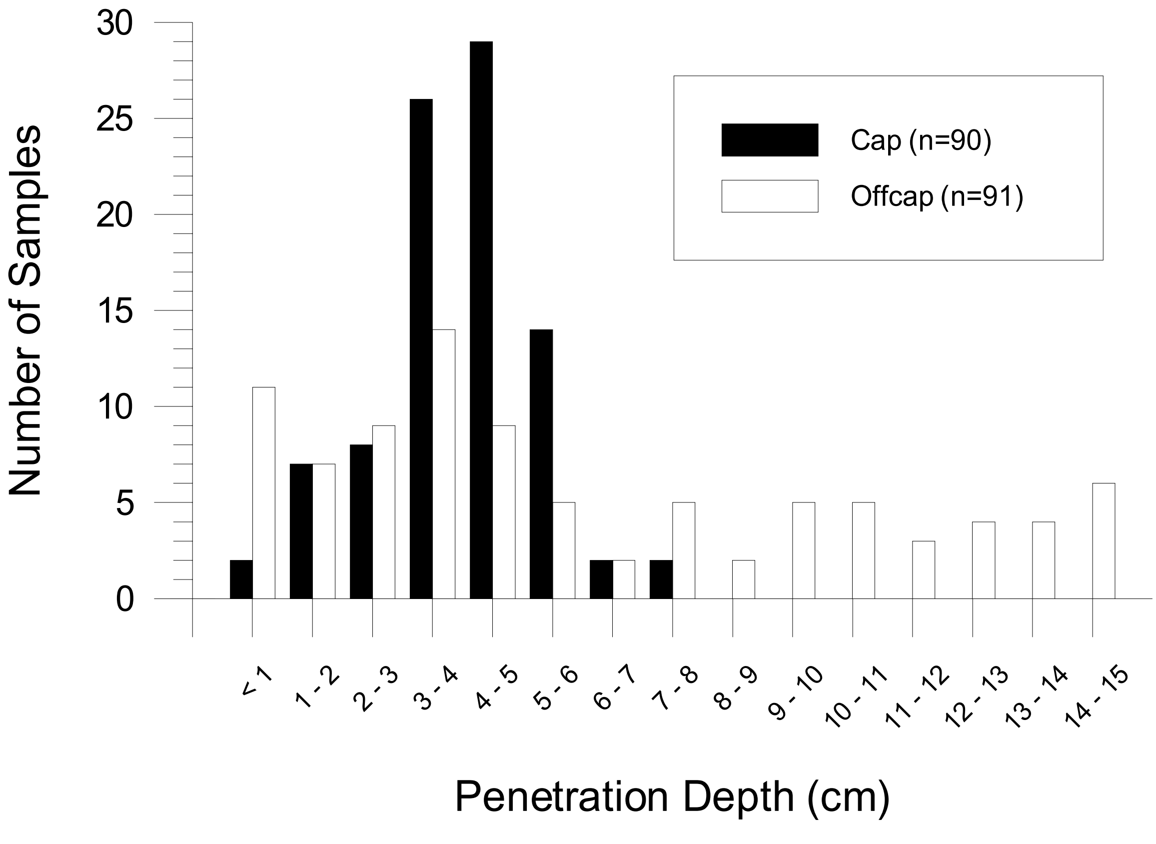


Figure 4-18. Frequency distribution of penetration depth (cm) for all replicate REMOTS® images obtained at the radial transect stations.

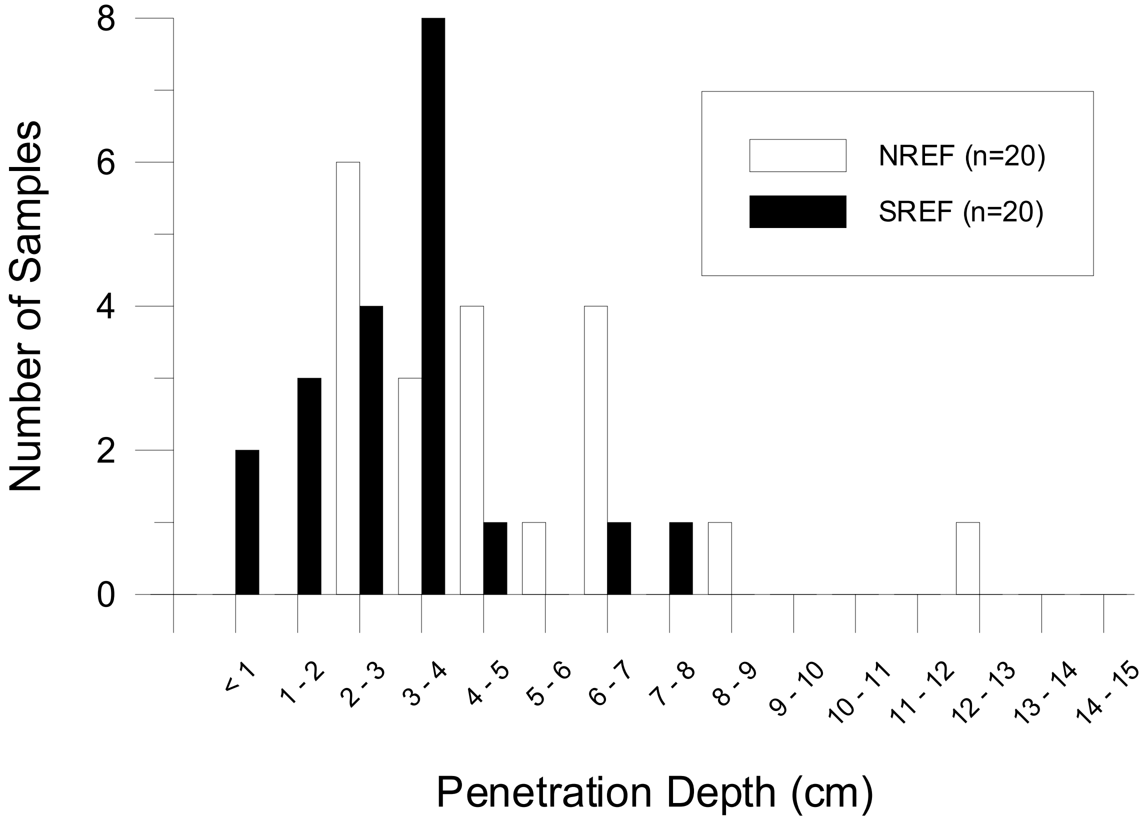


Figure 4-19. Frequency distribution of penetration depth (cm) for all replicate REMOTS® images obtained in the North and South Reference Areas.

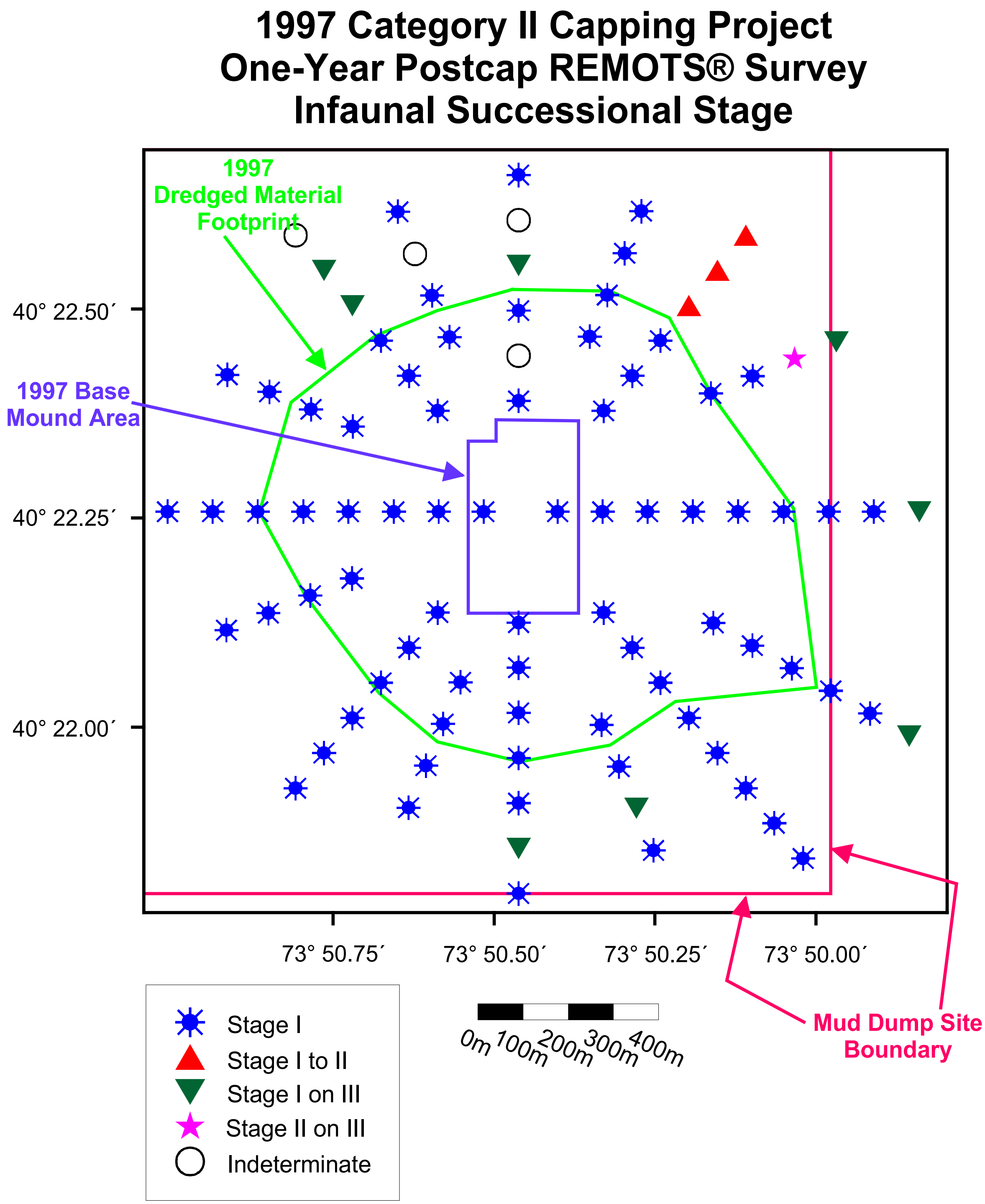


Figure 4-20. Infaunal successional stages at the radial transect stations.

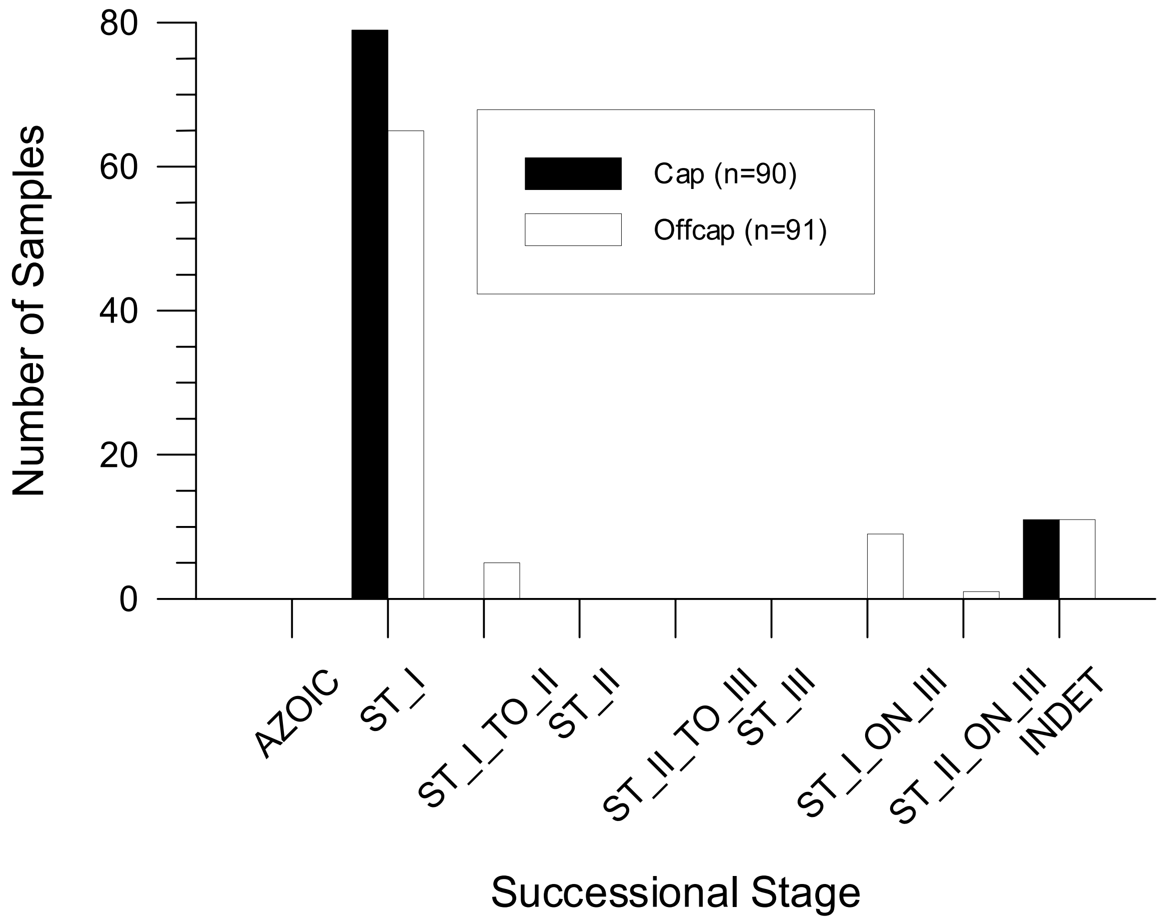


Figure 4-21. Frequency distribution of infaunal successional stage for all replicate REMOTS® images obtained at the radial transect stations.

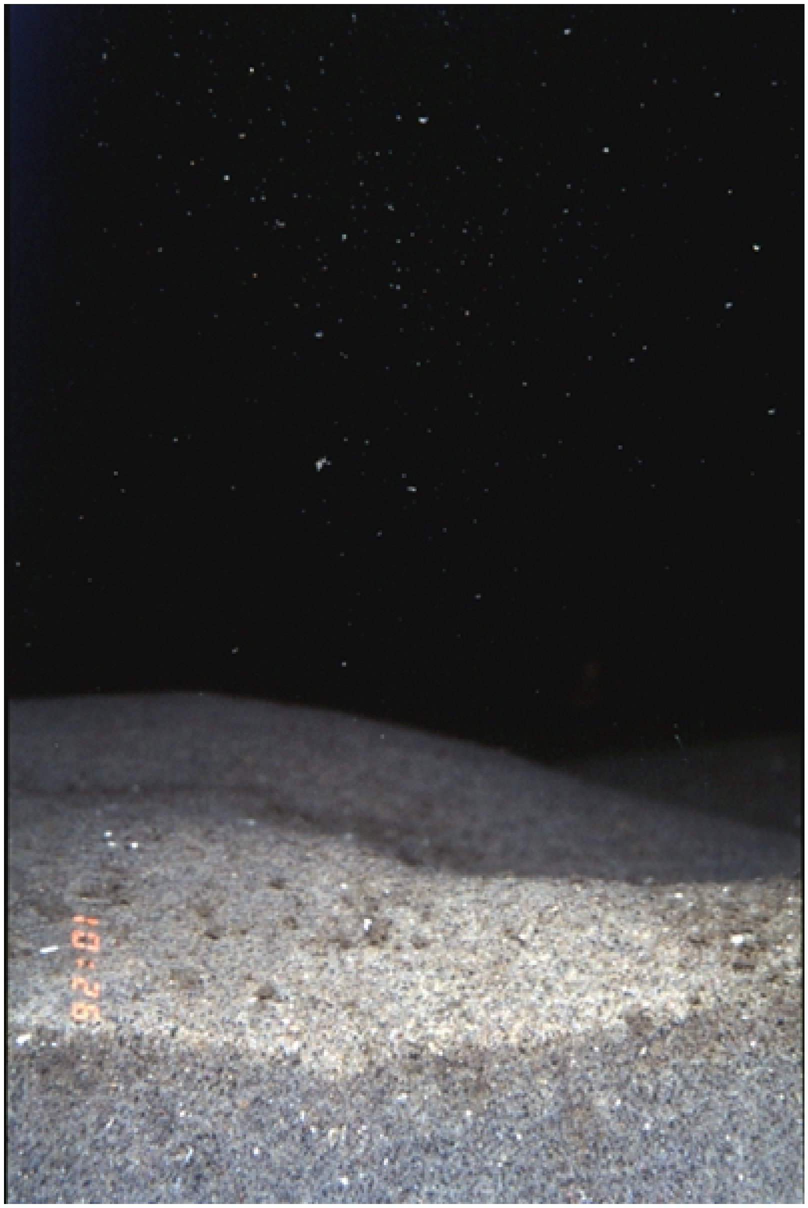


Figure 4-22. REMOTS® image from Station S-200 showing a dense mat of small Stage I polychaete tubes on the surface of the sand cap. Scale: image width = 15 cm.

Figure 4-23. REMOTS® image from Station NE-400 illustrating Stage I worms and Stage II *Nucula* sp. infaunal bivalves and a podocerid amphipod "stalk." Scale: image width = 15 cm.

Figure 4-24. REMOTS® image from Station ENE-200 illustrating Stage II *Nucula* sp. on top of Stage III feeding voids. Scale: image width = 15 cm.

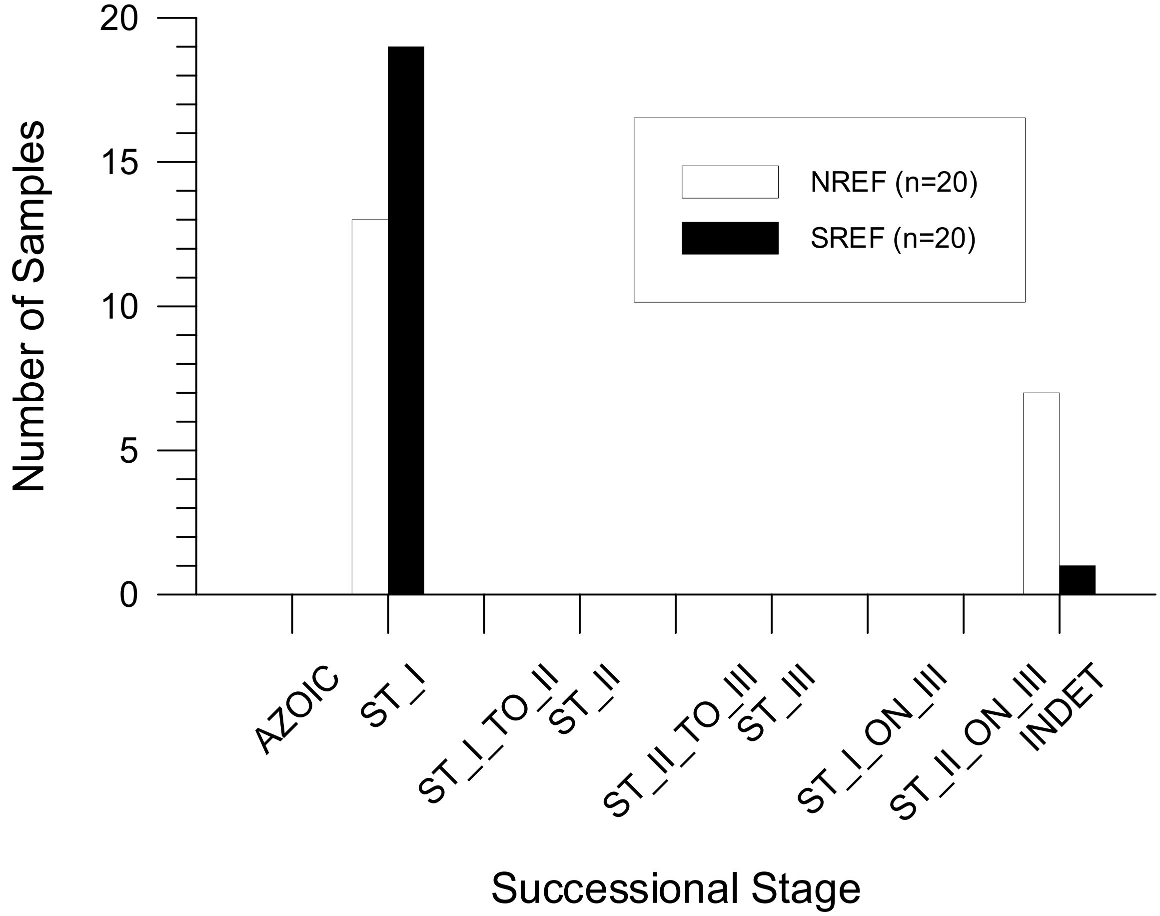


Figure 4-25. Frequency distribution of infaunal successional stage for all replicate REMOTS® images obtained in the North and South Reference Areas.

4.1.6 Apparent RPD Depths

Sands generally are characterized by low concentrations of hydrogen sulphide and/or iron sulphides and organic material, and therefore tend to lack an obvious color contrast to mark the division between aerobic and anaerobic zones in the sediment column. The lack of color contrast makes it difficult to measure the depth of the apparent RPD in REMOTS® images of sand. However, it is assumed that rippled sands in the New York Bight generally are well aerated as a result of both diffusion of oxygen from the overlying water and physical mixing associated with periodic bedload transport. Therefore, in REMOTS® images of sandy sediments, the depth of the apparent RPD typically is measured as being equal to or greater than the prism penetration depth.

At many stations located on the sand cap, average RPD depths generally ranged from 3 cm to greater than 5 cm (Figures 4-26 and 4-27). These relatively deep RPD depths reflect the widespread presence of the clean, rippled cap sand, which is assumed to be well-aerated to a depth exceeding the depth of prism penetration. Likewise, average RPD depths at the reference area stations were relatively deep (>3 cm) due to the widespread presence of sand (Figure 4-28). At the off-cap stations located on the outer reaches of several transects, relic dredged material was the principal sediment type encountered. Although the relic dredged material generally was very dark colored (e.g., Figure 4-13), suggesting high organic content, the average RPD values at most of these outer transect stations ranged from 2 to 5 cm (Figure 4-27). These are intermediate to deep RPD values which suggest that the surface sediments were well-oxygenated at these stations. This is attributed to fluid (pore water) and particle bioturbation by Stage III organisms inhabiting the fine-grained, organic-rich relic dredged material.

4.1.7 Organism-Sediment Index

Only five of the radial transect stations had indeterminate OSI values (Figure 4-29). This was due primarily to low prism penetration preventing RPD measurement and/or reliable determination of the infaunal successional stage. The frequency distribution of measured OSI values for the radial transect stations has a major mode of +7, with most values ranging from +4 to +7 (Figure 4-30). Overall, these are intermediate to high OSI values considered to be indicative of relatively healthy benthic habitat conditions. The highest OSI values were found at stations located on capped material, due in part to the estimated RPD depth (Figure 4-29).

At many of North Reference area stations, the OSI could not be calculated due to an indeterminate successional stage. For the stations within the North and South Reference Areas where an OSI was determined, the frequency distribution of values had a range of +2 to +7, with the majority of values falling at +7 (Figure 4-31). These are intermediate to high values reflecting the presence of Stage I organisms and the deep RPD depths determined in the rippled sand at these stations.

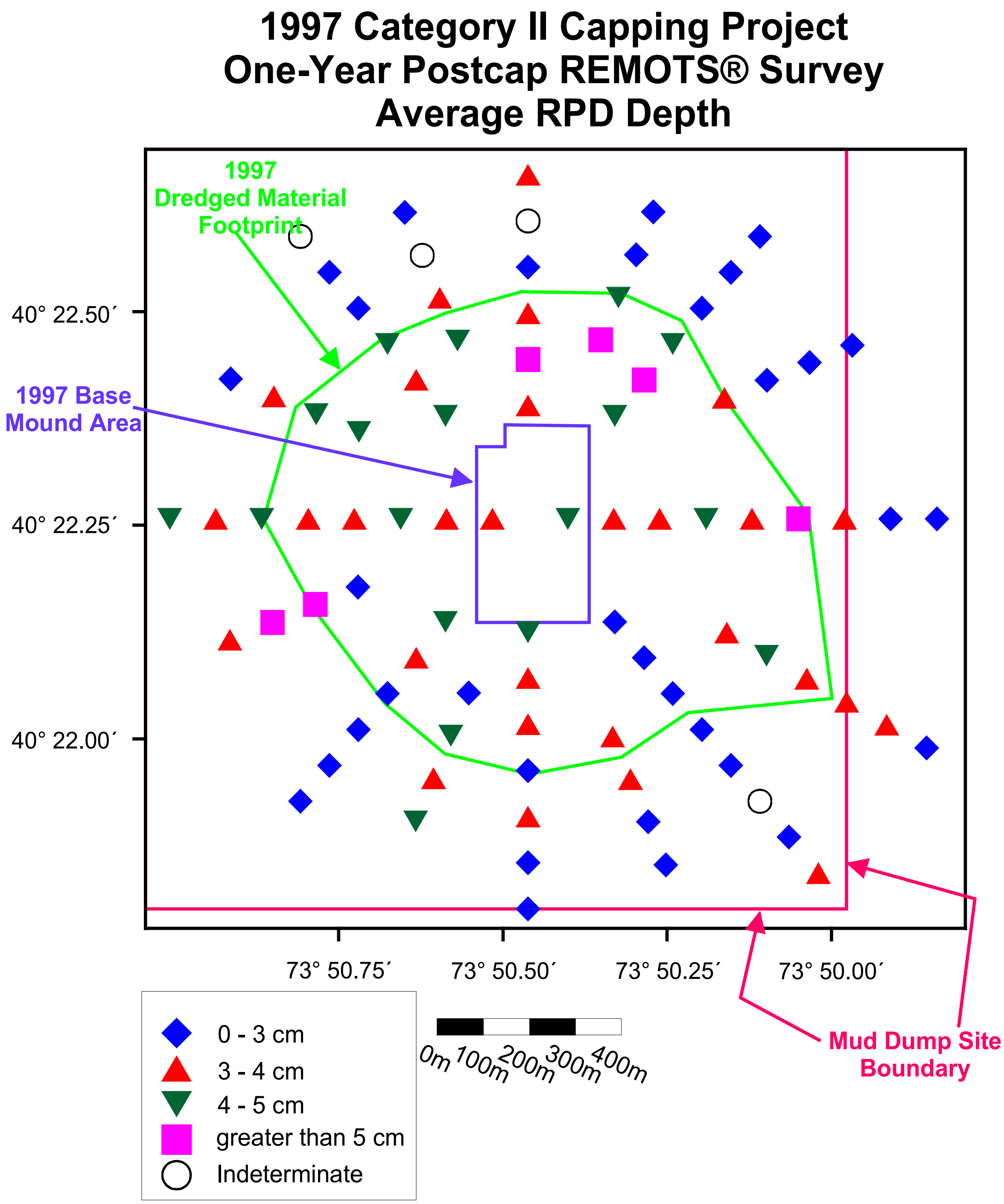


Figure 4-26. Average RPD depths at the radial transect stations.

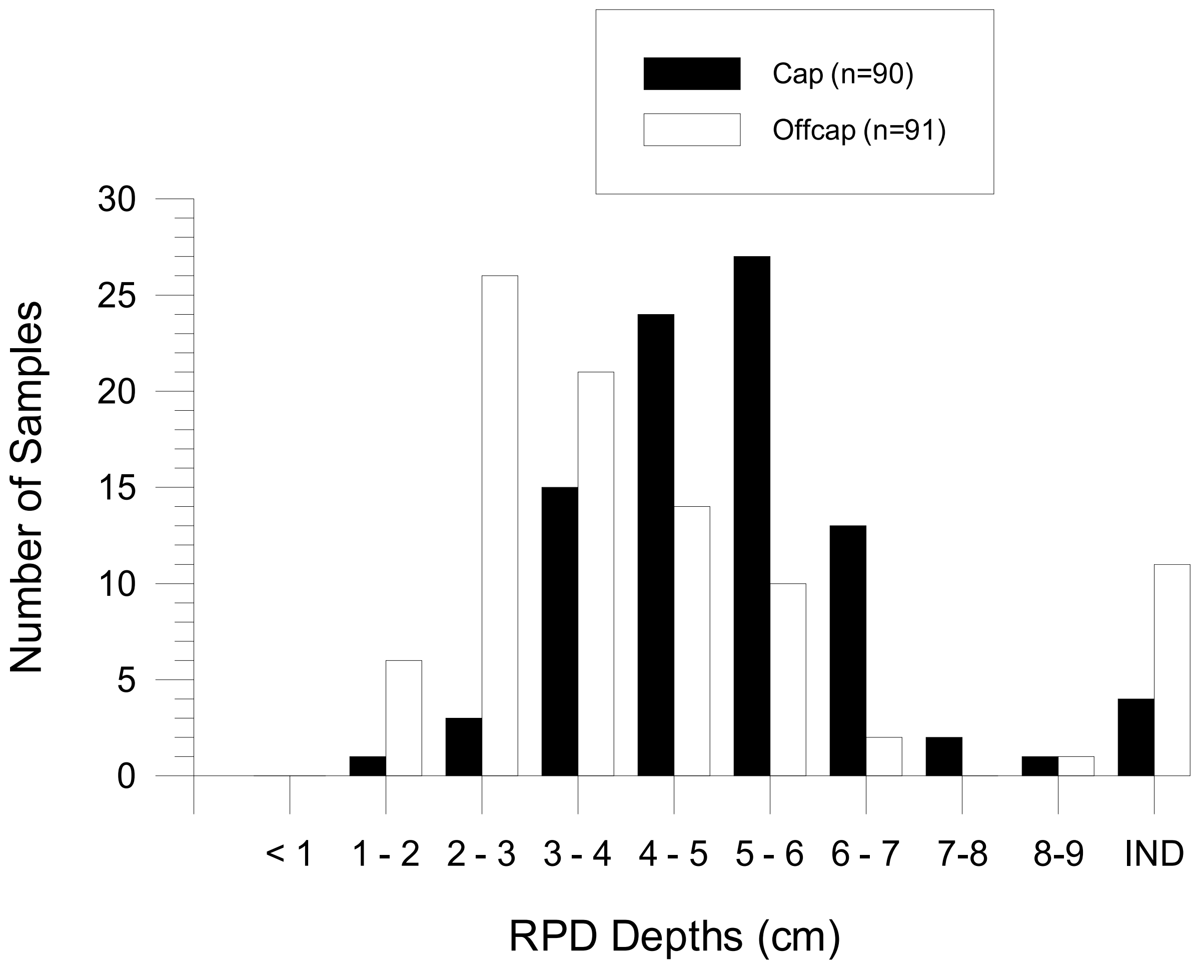


Figure 4-27. Frequency distribution of RPD depths (cm) for all replicate REMOTS® images obtained at the radial transect stations.

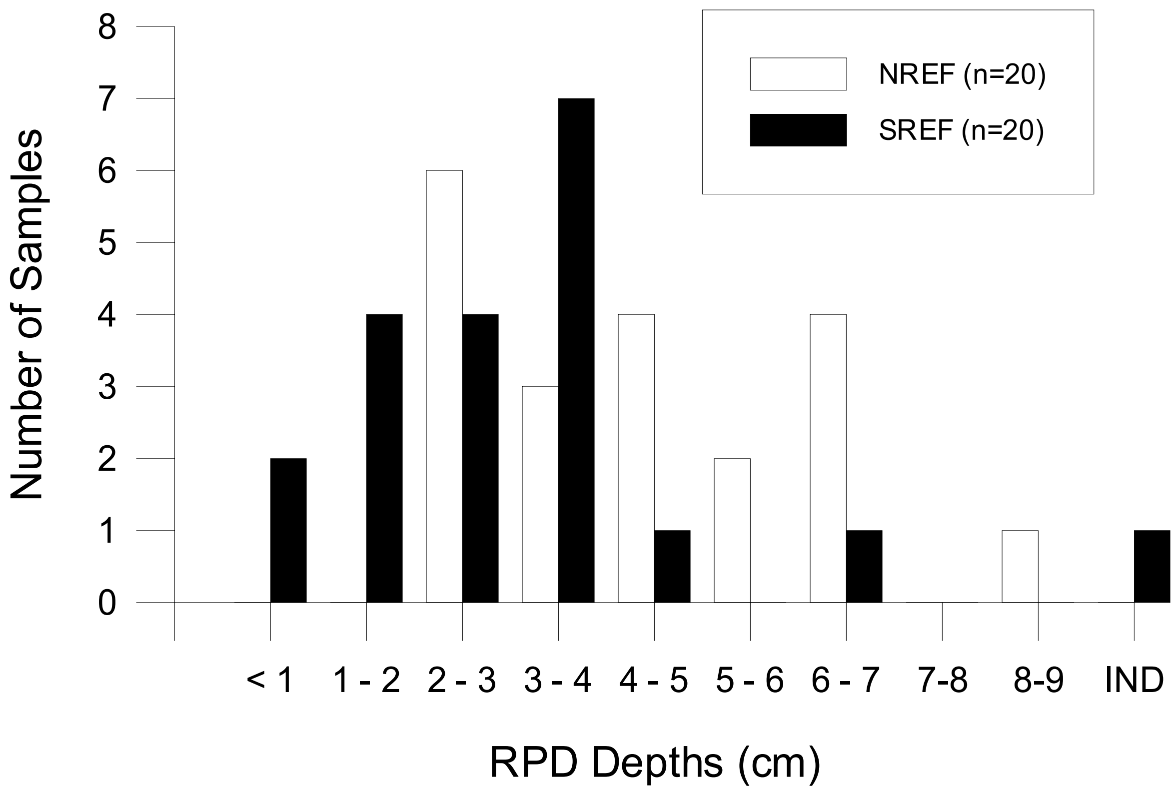


Figure 4-28. Frequency distribution of RPD depths (cm) for all replicate REMOTS® images obtained in the North and South Reference Areas.

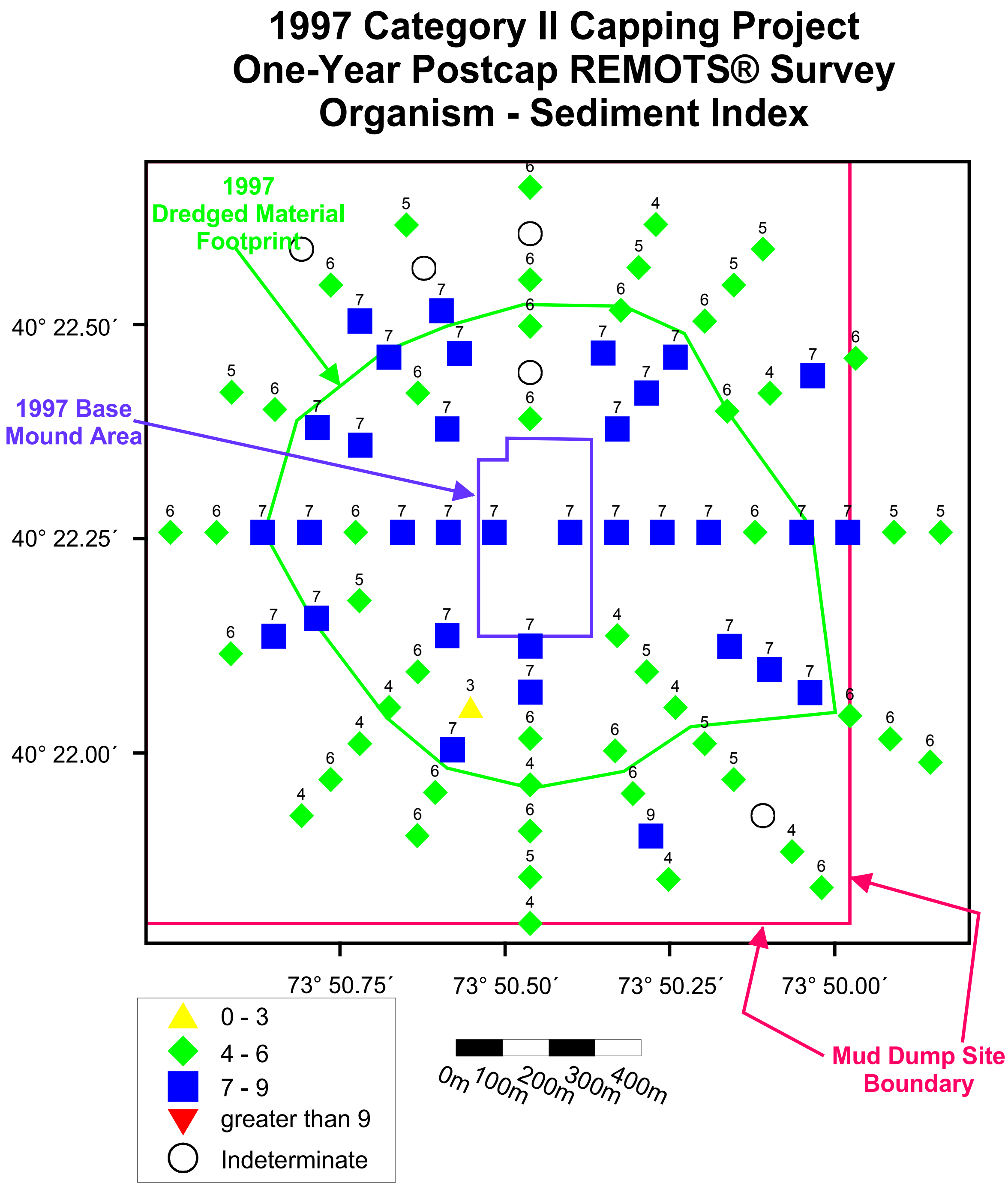


Figure 4-29. Average Organism-Sediment Index (OSI) values at the radial transect stations.

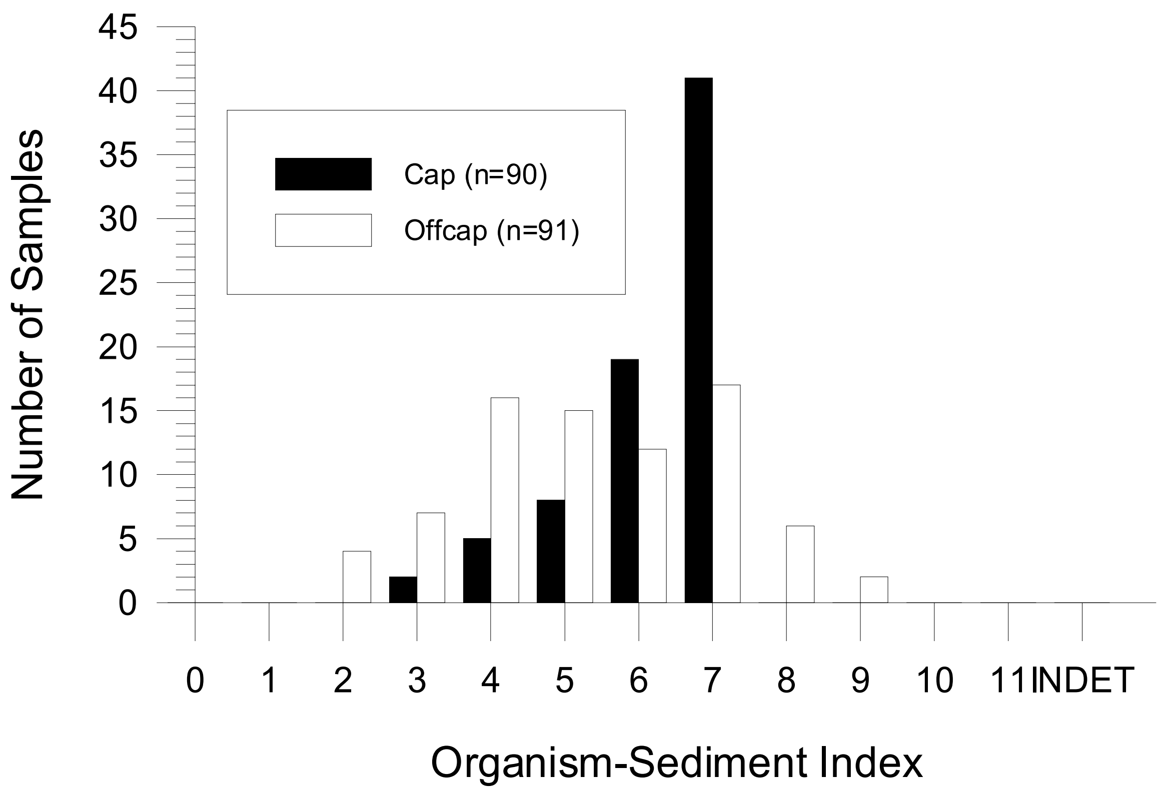


Figure 4-30. Frequency distribution of Organism-Sediment Index values for all replicate REMOTS® images obtained at the radial transect stations.

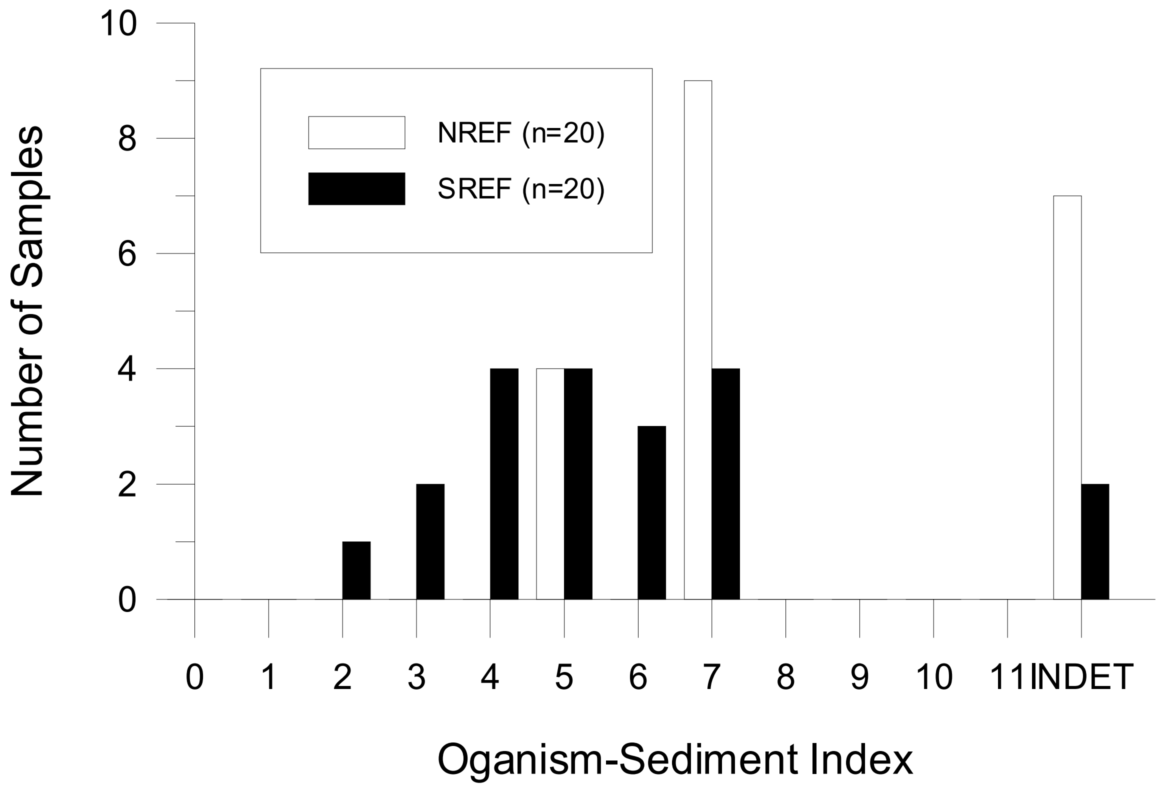


Figure 4-31. Frequency distribution of Organism-Sediment Index values for all replicate REMOTS® images obtained at the North and South Reference Area stations.

5.0 DISCUSSION

The objectives of this one-year postcap survey were to utilize high resolution bathymetry and REMOTS® sediment-profile imaging to monitor long-term stability of the 1997 Category II Capping Project sand cap and assess benthic infaunal colonization of the cap relative to ambient bottom conditions. In particular, the sampling design allows both for mapping the topography and horizontal distribution of the sand used for capping and evaluating overall benthic habitat quality on the sand cap and in surrounding areas. The information collected within the 1997 Category II Capping Project area, and at two nearby reference areas, should provide a comparative basis for assessing conditions in this region, particularly in terms of monitoring the long-term stability of the sand cap and the process of recolonization by benthic organisms.

5.1 Bathymetry and REMOTS® Characterization of the Capped Mound

There was a small but noticeable change in bathymetry between the April 1998 postcap survey and the April 1999 one-year postcap survey, however, the change is within the limits of resolution of the survey equipment (+/-0.5 ft). Figure 3-6 illustrates the depth difference results between postdisposal and one-year postcap bathymetric surveys. One meter or more of sand cap material is seen within the footprint. The negative values were only observed on Creamer's Ridge, an area of the disposed material mound which is known to have experienced a slope adjustment and consolidation. A subbottom survey in April 1998 confirmed that a 1-m thick layer of sand was distributed uniformly over the entire project area (SAIC 1998b).

The April 1999 one-year postcap REMOTS® survey, performed 14 months after cap placement, confirmed that stations within the capping area were dominated by rippled fine sand having an average grain size major mode of 3-2 phi. This clean, well-sorted sand, presumed to be the capping material from Ambrose Channel, was found at the sediment surface throughout the capping area. As illustrated in Figure 4-1, there was good agreement between the April 1999 REMOTS® and high-resolution bathymetric surveys in terms of mapping the horizontal distribution of the cap sand. Because REMOTS® can detect thin layers of sand on the outer flanks of the cap, the sand cap footprint defined using this technique extended roughly 50 to 200 meters beyond the footprint defined through high-resolution bathymetry (Figure 4-1).

The surface of the sand cap was rippled, suggesting that the sand is subject to periodic bedload transport. Similar sand ripples have been observed consistently at the surface of the 1993 Dioxin Capping Monitoring Project sand cap, but no significant net loss of this sand cap has been detected over the course of numerous monitoring surveys conducted between 1992 and 1997 (SAIC 1998c). Based on these results, it might be predicted that while the sand at the surface of the 1997 Category II Capping Project cap may experience periodic bedload transport, long-term loss of this capping material due to erosion is not expected.

Almost all the REMOTS® images obtained within the capping area had a sufficiently thick surface layer of sand that no underlying dredged material was observed. Of the REMOTS® stations on the sand cap, all but one station replicate showed homogeneous, compact sand extending from the sediment/water interface to the maximum penetration depth of the prism (from 2 to 5 cm at these stations). This cap distribution is not surprising since the April 1998 postcap coring survey of the project mound showed that cap thickness varied between 116 and 257 cm for all cores obtained within the capping boundary (SAIC 1998d).

Fine-grained dredged material was found just below the sediment surface in one replicate image at station ESE-100 on the sand cap (Figures 4-11 and 4-12). It is plausible that this material became entrained within the sand during cap placement activities. Another possibility is the material was stuck to the barge from a different operation and was dislodged during cap placement. Because the postcap bathymetric surveys and the postcap coring surveys all have shown a horizontally continuous cap with no regions of exposed project material, it is unlikely that the mud observed at Station ESE-100 is poorly-capped project material. It is, however, impossible to confirm this hypothesis as no physical sample of this material was acquired for geotechnical or chemical analysis.

5.2 REMOTS® Characterization of Areas Adjacent to the Capped Mound

Stations located outside the main capping area were more heterogeneous in sediment type than the cap, ranging from <-1 phi (gravel) to >4 phi (silt-clay). This heterogeneity reflects the wide variety of sediment types associated with earlier disposal projects. Some stations located outside the capping boundary showed a sand-over-mud layering that probably reflects coverage of historic dredged material by a thin layer of cap material (e.g., Figure 4-9). Uncapped relic dredged material was found at a number of stations to the northeast of the capping area, as well as at stations S-500 and S-600 on the south transect. Fine-grained, relic dredged material had been observed in both of these general locations during the May 1997 baseline (i.e., predisposal) REMOTS® survey (SAIC 1997a), as well as the first postcap REMOTS® survey (SAIC 1998e).

A few of the stations to the northwest of the capped mound had variable grain size, due to the presence of rocks, brick fragments, and coarse sand. This coarse material is presumed to be part of a broad scour lag deposit known to occur in the shallow mid-section of the MDS, near the peaks of several former disposal mounds. Camera prism penetration depths were greatest at off-cap stations located to the northeast and south of the capped mound, where the uncapped or thinly capped, soft dredged material from prior disposal projects was encountered. Prism penetration at some of these stations may have been enhanced by the bioturbation activities of Stage III infauna, leading to increased sediment water content and decreased compactness. The stations with relic dredged material were the only ones in this survey to have Stage III infauna present (Figures 4-9 and 4-18). Stage III taxa, in addition to requiring a physically stable habitat, also require a significant organic fraction in the sediment column for feeding. These requirements are best met on the older, silt-clay deposits adjacent to the capped mound.

Rippled fine to medium sand was the dominant grain size at both the North and South Reference areas; this sediment type is typical of ambient sediments throughout the New York Bight Apex. Consistent with the results of numerous previous surveys, the sand at the North Reference area was slightly coarser in texture (i.e., medium sand) than the fine sand found at the South Reference area. REMOTS® prism penetration depths at the North and South Reference areas were similar to those on the sand cap. This finding is to be expected as the grain size frequency distribution and successional status of the reference areas were similar to those of the cap material.

5.3 Assessment of Benthic Recolonization and Benthic Habitat Quality

The successional status of the sand cap remains in a nominal Stage I sere, as it was in the previous postcap REMOTS® survey of April 1998. The term "nominally" is used because the compactness of the sand prevented the camera from imaging evidence of Stage III taxa (i.e., deep feeding voids) that may exist below the relatively shallow penetration depths of the optical prism. However, it is considered unlikely that Stage III taxa were present. Many Stage III taxa have a preference for feeding in organic-rich muds and therefore the sand comprising the cap represents an unsuitable habitat for them. If they were present within or below the cap, it is expected that their feeding and bioturbation activities would result in decreased sediment compaction and deeper prism penetration, enabling the REMOTS® camera to detect them. The sand comprising the cap also experiences periodic bedload transport; such physical instability acts to curtail the normal successional sequence leading to the establishment of a mature Stage III community. Stage I species are adapted to physical instability and remain as the dominant colonizers of the sand cap. As long as the physical instability continues in the future, the benthic successional sequence is not expected to progress beyond the pioneering stage.

Based on the long-term monitoring results obtained under the 1993 Dioxin Capping Monitoring Project, surface-dwelling, Stage I polychaetes are the type of infauna expected to colonize the sand cap surface. These organisms typically have high population turnover rates, making them capable of rapidly exploiting new habitats like the sand cap as part of the early colonizing community. Their presence on the 1997 Category II Capping Project sand cap in early April 1998, as seen in the first postcap REMOTS® survey, and again during the one-year postcap survey, therefore is not surprising. The 1993 Dioxin Capping Monitoring Project results furthermore showed that the successional status of the sand cap remained at Stage I over the course of many years. This stage is adapted to the physical disturbance resulting from periodic bedload transport of the cap sand. Therefore, it is likely that the benthic successional sequence (recolonization) on the 1997 Category II Capping Project sand cap will not progress beyond the pioneering stage (Stage I) as observed in the April 1999 and April 1998 postcap surveys.

The widespread distribution of fine to medium rippled sands at the reference areas reflects a kinetic energy regime that is capable of moving sands as bedload transport. This physical process is important for preventing the accumulation of natural muddy deposits and defining the successional status of the ambient bottom. The successional designation in both reference areas was either Stage I or indeterminate, reflecting the physical instability of the benthic habitat in the broad region surrounding the disposal site. Unstable sands washed free of particulate organics tend to preclude the establishment of well-developed Stage III seres. These same factors are operating at the 1997 Category II Capping Project and are thus responsible for the convergence in sedimentary and biological properties of the sand cap material with characteristics of the reference areas.

Organism-Sediment Index values (OSIs) for both the radial transect and reference stations had a major mode of +7. In particular, an OSI of +7 was found at a number of stations located on the sand cap (Figure 4-22), reflecting relatively deep apparent RPD depths and the presence of Stage I recolonizing benthic organisms at these stations. The similarity in OSI values between these sand cap stations and many of the reference stations suggests that portions of the 1997 Category II Capping Project sand cap have become comparable to the ambient bottom outside of the former Mud Dump Site in terms of overall benthic habitat quality.

OSI values were not calculated for a only few of stations on the sand cap and in the reference areas due to indeterminate successional stage determinations. Overall, these results show that Stage I organisms had a uniform distribution on the sand cap at the time of the survey, 14 months following the completion of capping operations. It was anticipated that as a result of on-going recolonization Stage I organisms would be more widespread during the one-year postcap survey than the patchy distribution found during the first postcap REMOTS® survey in April 1998.

Because bottom sediments in this part of the inner continental shelf are dominated by physical processes, OSI values at the upper range of the scale (e.g., +9, +10, and +11) are not expected to be achieved on either the sand cap or in the reference areas. Benthic succession beyond Stage I is arrested or retrograded by physical instability of the bottom, and redox potential discontinuity (RPD) depths are dominantly controlled by physical rather than biological factors. Thus, in becoming comparable to the ambient bottom, areas of the 1997 Category II Capping Project sand cap have likely reached their highest potential as a benthic habitat as defined by the REMOTS® OSI.

Off-cap stations in the area surrounding the sand cap had average OSI values ranging between +4 and +9, with most values greater than +6 (Figure 4-26). These OSI values are generally considered to be indicative of intermediate to high benthic habitat quality. In the baseline REMOTS® survey of May 1997, stations in the area surrounding the 1997 base mound area had intermediate OSI values ranging from +3 to +7, suggesting intermediate benthic habitat quality. These results suggest that benthic habitat quality in the area surrounding the capped project mound has not been adversely affected by the capping operations, and may even have improved slightly between the May 1997 baseline and April 1999 postcap surveys. This may be related to deepening of average RPD depths as a result of bioturbation by Stage III organisms at a number of stations, particularly those having relic-dredged material to the northeast of the capped project mound.

6.0 SUMMARY

The one-year postcap bathymetric and REMOTS® surveys conducted under the 1997 Category II Capping Project at the New York Mud Dump Site took place in March and April 1999, approximately 14 months following the completion of capping operations. The objectives of this survey were to 1) to detect any changes in the topography of the capped project mound that might indicate a loss of sand cap material, and 2) to assess overall benthic habitat quality and recolonization of the sand cap.

The bathymetry survey confirmed that there has been little or no change in the topography of the capped mound since the first postcap survey of April 1998. The REMOTS® survey confirmed that stations within the capping area were dominated by rippled fine sand having an average grain size major mode of 3-2 phi. This clean, well-sorted sand, presumed to be the capping material from Ambrose Channel, was found at the sediment surface throughout the capping area. There was good agreement between the April 1999 one-year postcap REMOTS® and high-resolution bathymetric surveys in terms of mapping the horizontal distribution of the cap sand. The REMOTS® images showed that thin layers of the cap sand extended roughly 50 to 200 meters beyond the sand cap footprint defined through high-resolution bathymetry. Based on the combined bathymetric and REMOTS® results, it can be concluded that the sand cap has remained stable since its placement in January 1998.

The REMOTS® results indicated that benthic organisms continued to colonize the surface of the sand cap at the time of the survey. The REMOTS® results indicated that areas of the sand cap had been successfully colonized by surface-dwelling, opportunistic, Stage I polychaetes. Benthic succession beyond Stage I is not likely to occur on the sand cap or in the reference areas due to the physical instability of the bottom associated with the bedload transport of the sand.

Sediments in areas immediately adjacent to the sand cap ranged from gravel to silt-clay, reflecting a wide variety of sediment types associated with past disposal activities in the southeast corner of the former Mud Dump Site. Uncapped relic dredged material was found in some of the adjacent areas, particularly to the northeast of the sand cap. This fine-grained, relic dredged material was covered by a thin surface layer of cap sand at some of the stations near the sand cap perimeter. Rippled fine to medium sand, typical of ambient sediments throughout the New York Bight Apex, was found to be the dominant grain size at both the North and South Reference areas.

An average Organism-Sediment Index value of +7 was found at a significant number of stations on the sand cap and in the reference areas. OSI values greater than +6 generally indicate good overall benthic habitat quality. On the sand cap and in the reference areas, the OSI values greater than +6 reflected relatively deep apparent RPD depths and the presence of Stage I benthic organisms. The similarity in OSI values between the sand cap stations and many of the reference stations suggests that portions of the sand cap had become comparable to the ambient bottom outside of the Mud Dump Site in terms of overall benthic habitat quality. OSI values greater than +6 also were found consistently at stations surrounding the sand cap. These results suggest that benthic habitat quality in the areas adjacent to the capped project mound were not adversely affected by the capping operations.

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APPENDIX A

REMOTS® IMAGE ANALYSIS DATA

Abbreviations:

STAT = station
REPL = replicate
DATE = date
TIME = time
LAT = station latitude
LONG = station longitude
SS = successional stage
GSMX = maximum grain size (phi units)
GSMN = minimum grain size (phi units)
GSMM = grain size major mode (phi units)
PNRNG = penetration range (boundary roughness, in cm)
PENMEAN = mean penetration (cm)
DMMEAN = mean thickness of dredged material (cm)
Dm = dredged material present/absent
RPDMEAN = mean RPD depth (cm)
OSI = Organism-Sediment Index (99 = indeterminate)
SURF = origin of boundary roughness (biogenic or physical)
FULL CMNT = full comment

STAT	REPL	DATE	TIME	AYST	LAT	LONG	SS	GSMX	GSMN	GSMM	PNMN	PNMX	PNRNG	PENMEAN	RPDCNT	RPDAREA	RPDMN	RPDMX	RPDMEAN	OSI	SURF	LODO	FULL CMNT
E0	A	4/27/99	11:56	MCS	40.37102	-73.8400	ST_I	2	4	3 to 2	3.03	4.21	1.18	3.62	1	48.777	3.03	4.26	3.49	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
E0	C	4/27/99	11:58	MCS	40.37105	-73.8400	ST_I	2	4	3 to 2	4.82	5.49	0.67	5.16	1	69.813	4.36	5.33	4.97	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SNAIL SHELL @ SURF
E100	A	4/27/99	11:47	MCS	40.37099	-73.8388	ST_I	2	4	3 to 2	4.05	4.56	0.51	4.31	1	57.389	4	4.36	4.14	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
E100	C	4/27/99	11:48	MCS	40.37099	-73.8388	ST_I	3	4	3 to 2	3.44	3.95	0.51	3.69	1	49.362	3.08	3.95	3.53	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SHELL PIECES
E200	A	4/27/99	11:37	MCS	40.37101	-73.8377	ST_I	3	4	3 to 2	2.36	4.62	2.26	3.49	1	52.523	2.21	4.67	3.77	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
E200	B	4/27/99	11:40	MCS	40.37102	-73.8377	ST_I	2	4	3 to 2	3.33	3.64	0.31	3.49	1	46.049	2.92	3.59	3.28	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
E300	A	4/27/99	11:30	MCS	40.37097	-73.8366	INDET	3	4	3 to 2	2.87	3.44	0.56	3.15	1	41.944	2.56	3.54	2.99	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
E300	B	4/27/99	11:30	MCS	40.37094	-73.8366	ST_I	2	4	3 to 2	5.59	7.59	2	6.59	1	92.225	5.08	7.49	6.65	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
E400	A	4/27/99	11:01	MCS	40.37096	-73.8354	ST_I	2	4	3 to 2	2.87	6	3.13	4.44	1	48.468	2.51	5.38	3.47	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
E400	B	4/27/99	11:01	MCS	40.37095	-73.8354	ST_I	2	4	3 to 2	3.23	4.46	1.23	3.85	1	52.225	3.13	4.56	3.73	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
E500	A	4/27/99	10:54	MCS	40.37096	-73.8342	ST_I	2	4	3 to 2	3.9	5.69	1.79	4.79	1	69.728	3.74	5.69	4.95	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
E500	C	4/27/99	10:55	MCS	40.37099	-73.8342	ST_I	2	4	3 to 2	6.36	9.28	2.92	7.82	1	100.118	2.77	9.13	7.12	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
E600	A	4/27/99	10:47	MCS	40.37102	-73.8330	ST_I	3	>4	4 to 3	3.23	4.31	1.08	3.77	1	52.642	3.33	4.26	3.76	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; SULFIDIC PATCHES; ORG FLOC @ SURF
E600	C	4/27/99	10:48	MCS	40.37098	-73.8330	ST_I	3	4	4 to 3	2.46	5.03	2.56	3.74	1	43.346	2.15	4.87	3.08	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
E700	A	4/27/99	10:41	MCS	40.37103	-73.8319	ST_I	3	>4	>4	10.26	10.67	0.41	10.46	1	43.176	2.05	4.72	3.18	6	BIOGENIC	NO	HIST DM>P; SHELL @ SURF; MOTTLED RED CLAY @ Z
E700	B	4/27/99	10:41	MCS	40.37104	-73.8318	ST_I	3	>4	>4	9.38	10.15	0.77	9.77	2	9.737	0.05	3.74	1.58	4	BIOGENIC	NO	HIST DM>P; MOTTLED RED CLAY @ RT
E800	A	4/27/99	10:34	MCS	40.37099	-73.8307	ST_I	3	>4	>4	7.28	7.74	0.46	7.51	1	17.832	0.36	3.69	1.39	3	PHYSICAL	NO	HIST DM>P; SHELL PIECE NEAR SURF; COPPER TUBING?
E800	C	4/27/99	10:35	MCS	40.37097	-73.8308	ST_I_ON_III	3	>4	>4	6.15	6.67	0.51	6.41	2	7.757	0.05	2.87	1.21	7	PHYSICAL	NO	HIST DM>P; TUBES; BURROW; WORM @ Z; PEBBLES
ENE0	A	4/27/99	10:02	MCS	40.37332	-73.8361	ST_I	2	>4	4 to 3	2.56	3.28	0.72	2.92	1	31.438	2.31	3.33	2.69	5	PHYSICAL	NO	CAP S/M; RIPPLED; SM PATCH HIST DM @ BOT RT; SHELL PIECE @ SURF
ENE0	C	4/27/99	10:03	MCS	40.37337	-73.8361	ST_I	2	4	3 to 2	2.92	5.28	2.36	4.1	1	61.562	2.36	5.18	4.42	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
ENE100	A	4/27/99	10:10	MCS	40.37366	-73.8349	ST_I	3	>4	4 to 3	3.59	4.36	0.77	3.97	1	24.809	1.03	2.41	1.77	4	BIOGENIC	NO	SM>P; HIST DM>P; ORG FLOC @ SURF; LOTS TUBES
ENE100	B	4/27/99	10:11	MCS	40.37366	-73.8349	ST_I	3	>4	4 to 3	3.38	3.85	0.46	3.62	1	28.21	1.28	3.38	2.14	4	BIOGENIC	NO	SM>P; HIST DM>P; LOTS TUBES; VOID; ORG FLOC @ SURF
ENE200	A	4/27/99	10:16	MCS	40.37408	-73.8339	ST_II_ON_III	4	>4	>4	14.77	15.08	0.31	14.92	1	34.156	0.67	3.9	2.48	9	BIOGENIC	NO	HIST DM>P; VOIDS; BURROWS; TUBES; NUCULA; WORMS @ Z
ENE200	B	4/27/99	10:17	MCS	40.37406	-73.8339	ST_I	4	>4	>4	14.65	15.03	0.37	14.84	2	9.322	0.05	3.64	2.22	4	PHYSICAL	NO	HIST DM>P; TUBES; SHELL PIECE; WIPER CLASTS/SMEARS
ENE300	A	4/27/99	10:25	MCS	40.37434	-73.8327	ST_I	4	>4	>4	14.41	14.82	0.41	14.62	1	23.837	0.51	2.92	1.76	4	BIOGENIC	NO	HIST DM>P; TUBES; WORMS @ Z
ENE300	C	4/27/99	10:25	MCS	40.37434	-73.8327	ST_I_ON_III	4	>4	>4	14.77	15.54	0.77	15.15	2	11.776	0.05	4.67	2.04	8	BIOGENIC	NO	HIST DM>P; VOIDS; BURROWS; WORM TUBES; WIPER CLASTS/SMEARS
ESE0	A	4/28/99	13:27	MCS	40.36880	-73.8360	ST_I	2	4	3 to 2	3.12	5.11	1.99	4.11	1	58.227	2.8	5.22	4.14	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE0	B	4/28/99	13:28	MCS	40.36885	-73.8360	ST_I	2	4	3 to 2	2.47	4.35	1.88	3.41	1	48.938	2.58	4.57	3.48	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE100	B	4/28/99	13:23	MCS	40.36835	-73.8350	ST_I	2	4	3 to 2	3.76	4.52	0.75	4.14	1	58.404	2.96	4.57	4.18	7	PHYSICAL	NO	CAP S>P; ORG FLOC; RPD>P; SHELL HASH @ Z
ESE100	C	4/28/99	13:23	MCS	40.36834	-73.8350	ST_I	2	>4	3 to 2	6.88	7.58	0.7	7.23	1	76.354	4.68	6.34	5.51	7	PHYSICAL	NO	CAP S/HIST DM?; RIPPLED; RPD=S LAYER
ESE200	B	4/28/99	13:14	MCS	40.36792	-73.8339	ST_I	2	4	4 to 3	2.8	3.71	0.91	3.25	1	44.135	2.69	3.49	3.13	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE200	C	4/28/99	13:16	MCS	40.36791	-73.8340	ST_I	2	4	3 to 2	3.39	4.68	1.29	4.03	1	55.12	3.28	4.78	3.94	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE300	B	4/28/99	13:09	MCS	40.36749	-73.8330	ST_I	2	4	3 to 2	1.94	4.57	2.63	3.25	1	37.917	1.94	4.68	2.68	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE300	C	4/28/99	13:09	MCS	40.36749	-73.8330	ST_I	2	4	3 to 2	2.41	5.35	2.94	3.88	1	47.042	2.41	5.19	3.4	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
ESE400	A	4/28/99	13:00	MCS	40.36693	-73.8319	ST_I	2	4	4 to 3	3.44	4.46	1.02	3.95	1	51.219	3.23	4.41	3.71	6	PHYSICAL	NO	AMBIENT S>P; RIPPLED; ORG FLOC; RPD>P; TUBES; BRICK FRAG
ESE400	C	4/28/99	13:02	MCS	40.36696	-73.8320	ST_I	2	4	4 to 3	1.67	3.87	2.2	2.77	1	34.142	1.56	3.71	2.43	5	PHYSICAL	NO	AMBIENT S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
ESE500	D	4/29/99	11:37	MCS	40.36652	-73.8309	ST_I	-1	>4	>4	3.06	5.11	2.04	4.09	1	23.746	0.16	3.66	1.98	4	PHYSICAL	NO	HIST DM>P?; ROCKS; SEA STAR; BRICK FRAGS
ESE500	E	4/29/99	11:38	MCS	40.36649	-73.8309	ST_I_ON_III	-1	>4	>4	3.6	4.46	0.86	4.03	1	25.128	0.59	3.33	1.85	8	BIOGENIC	NO	HIST DM>P?; VOID; ROCKS; TUBES; BRICK FRAGS
N0	A	4/27/99	8:44	MCS	40.37318	-73.8410	INDET	2	4	3 to 2	3.56	5.57	2.01	4.56	1	61.877	3.56	5.67	4.4	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
N0	B	4/27/99	8:45	MCS	40.37315	-73.8410	ST_I	2	4	3 to 2	2.47	3.87	1.39	3.17	1	44.929	2.01	3.87	3.13	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC @ SURF; RPD>P
N100	B	4/27/99	8:38	MCS	40.37412	-73.8411	INDET	2	4	3 to 2	4.95	6.44	1.49	5.7	1	82.766	2.58	6.7	5.93	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
N100	C	4/27/99	8:40	MCS	40.37409	-73.8411	INDET	2	4	3 to 2	3.61	4.9	1.29	4.25	1	58.832	1.91	5.1	4.12	99	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC @ SURF; RPD>P
N200	B	4/27/99	8:33	MCS	40.37502	-73.8411	INDET	2	4	3 to 2	3.35	5.21	1.86	4.28	1	54.045	2.94	5.21	3.85	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
N200	C	4/27/99	8:34	MCS	40.37499	-73.8411	ST_I	2	4	3 to 2	2.73	4.79	2.06	3.76	1	51.451	2.47	4.79	3.64	6	PHYSICAL	NO	CAP S>P; RIPPLED; FEW SM ROCKS; RPD>P
N300	A	4/27/99	8:26	MCS	40.37587	-73.8410	ST_I_ON_III	2	>4	>4	9.38	10.15	0.77	9.77	1	8.413	0.05	0.98	0.6	6	PHYSICAL	NO	HIST DM>P; VOIDS; BURROWS
N300	C	4/27/99	8:27	MCS	40.37587	-73.8411	ST_I_ON_III	2	>4	4 to 3	7.47	7.68	0.21	7.58	1	5.646	0.05	0.98	0.42	6	BIOGENIC	NO	HIST DM>P; VOID; WORM @ Z
N400	A	4/27/99	8:19	MCS	40.37681	-73.8410	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	PHYSICAL	NO	NO PEN; HARD BOT; BRICK AND BRICK FRAGS; SOME ROCKS
N400	C	4/27/99	8:22	MCS	40.37679	-73.8411	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	PHYSICAL	NO	NO PEN; HARD BOT; BRICK AND BRICK FRAGS COVERED W/ ORG DETRITUS
N500	A	4/27/99	8:10	MCS	40.37767	-73.8411	ST_I	2	4	4 to 3	2.06	4.48	2.42	3.27	1	49.102	2.16	4.54	3.48	6	PHYSICAL	NO	S>P; RIPPLED; RPD>P
N500	B	4/27/99	8:12	MCS	40.37770	-73.8410	ST_I	2	4	4 to 3	1.39	4.59	3.2	2.99	1	38.494	1.7	4.54	2.7	5	PHYSICAL	NO	S>P; RIPPLED; RPD>P; SHELL HASH @ SURF
NE0	A	4/27/99	9:50	MCS	40.37299	-73.8388	ST_I	2	4	3 to 2	2.72	5.79	3.08	4.26	1	60.466	2.36	5.95	4.36	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF
NE0	B	4/27/99	9:51	MCS	40.37299	-73.8389	ST_I	3	4	4 to 3	2.92	5.9	2.97	4.41	1	59.231	2.67	5.69	4.25	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NE100	A	4/27/99	9:44	MCS	40.37375	-73.8381	ST_I	2	4	3 to 2	4.62	5.79	1.18	5.21	1	73.75	2.21	5.74	5.21	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NE100	B	4/27/99	9:44	MCS	40.37371	-73.8380	ST_I	2	4	3 to 2	4.21	6.56	2.36	5.39	1	76.925	3.59	6.46	5.46	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; FLOC DRAGDOWN
NE200	A	4/27/99	9:21	MCS	40.37439	-73.8373	ST_I	2	4	4 to 3	3.08	5.9	2.82	4.49	1	59.074	3.03	5.9	4.19	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC @ SURF; SM SHELL BITS
NE200	C	4/27/99	9:22	MCS	40.37439	-73.8374	ST_I	2	4	3 to 2	4.36	5.44	1.08	4.9	1	67.541	4.21	5.54	4.8	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NE300	A	4/27/99	15:06	MCS	40.37513	-73.8365	ST_I	2	4	4 to 3	2.16	3.87	1.7	3.02	1	42.557	2.06	3.76	3.02	6	PHYSICAL	NO	S>P; RIPPLED; RPD>P; SHELL FRAGS @ SURF
NE300	B	4/27/99	15:07	MCS	40.37514	-73.8366	ST_I_TO_II	2	>4	4 to 3	5	5.26	0.26	5.13	1	27.331	1.24	2.84	1.96	5	PHYSICAL	NO	S/HIST DM; LOTS WORMS @ Z
NE400	A	4/27/99	15:13	MCS	40.37578	-73.8359	ST_I_TO_II	3	>4	>4	10.05	13.25	3.2	11.65	1	19.19	0.05	3.14	1.95	5	BIOGENIC	NO	HIST DM>P; RIPPLED; TUBES; WORMS @ Z; AMPHIPOD STALK
NE400	C	4/27/99	15:14	MCS	40.37582	-73.8359	ST_I	3	>4	>4	10.93	12.27	1.34	11.6	1	24.485	0.41	3.87	2.16	4	BIOGENIC	NO	HIST DM>P; RIPPLED; LOTS WORMS @ Z; WIPER CLAST/SMEARS
NE500	A	4/27/99	15:21	MCS	40.37652	-73.8350	ST_I_TO_II	3	>4	>4	14.48	15	0.52	14.74	1	28.266	0.77	2.84	2.03	5	BIOGENIC	NO	HIST DM>P; TUBES; WORMS @ Z
NE500	B	4/27/99	15:21	MCS	40.37657	-73.8351	ST_I_TO_II	3	>4	>4	13.61	14.23	0.62	13.92	1	17.286	0.1	2.01	1.3	4	BIOGENIC	NO	HIST DM>P; TUBES; WORMS @ Z
NNE0	A	4/27/99	9:12	MCS	40.37446	-73.8391	ST_I	2	4	3 to 2	4.51	5.54	1.03	5.03	1	66.743	4.21	5.13	4.74	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P

STAT	REPL	DATE	TIME	AYST	LAT	LONG	SS	GSMX	GSMN	GSMM	PNMN	PNMX	PNRNG	PENMEAN	RPDCNT	RPDAREA	RPDMN	RPDMX	RPDMEAN	OSI	SURF	LODO	FULL CMNT
NNE0	B	4/27/99	9:13	MCS	40.37446	-73.8392	ST_I	2	4	3 to 2	5.08	5.85	0.77	5.46	1	74.131	4.77	5.85	5.32	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NNE100	A	4/27/99	9:02	MCS	40.37535	-73.8387	ST_I	2	4	3 to 2	6.39	6.91	0.52	6.65	1	89.54	6.19	6.86	6.39	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NNE100	B	4/27/99	9:03	MCS	40.37529	-73.8387	ST_I	2	4	3 to 2	1.9	2.82	0.92	2.36	1	29.304	1.69	3.03	2.08	4	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NNE200	A	4/27/99	8:57	MCS	40.37616	-73.8382	ST_I	3	>4	>4	12.94	13.71	0.77	13.32	1	7.569	0.11	1.12	0.7	2	BIOGENIC	NO	HIST DM>P; WORM @ Z
NNE200	B	4/27/99	8:57	MCS	40.37614	-73.8383	ST_I	3	>4	>4	9.23	10.05	0.82	9.64	1	60.281	1.96	6.19	4.54	7	PHYSICAL	NO	S/DM; WIPER CLASTS/SMEARS; WORMS @ Z
NNE300	A	4/27/99	15:00	MCS	40.37705	-73.8378	ST_I	4	>4	>4	12.68	13.35	0.67	13.02	1	37.963	1.91	4.54	2.72	5	BIOGENIC	NO	HIST DM>P; TUBES; WORMS @ Z
NNE300	B	4/27/99	15:01	MCS	40.37704	-73.8378	ST_I	4	>4	>4	13.14	13.45	0.31	13.3	1	6.824	0.05	1.24	0.59	2	BIOGENIC	NO	HIST DM>P; TUBES; BIG WORM @ Z ON RT
NNW0	A	4/27/99	14:34	MCS	40.37450	-73.8427	ST_I	2	4	4 to 3	3.14	4.9	1.75	4.02	1	58.39	2.53	5.1	4.17	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
NNW0	C	4/27/99	14:37	MCS	40.37451	-73.8429	ST_I	2	4	4 to 3	3.71	5.26	1.55	4.48	1	59.044	3.35	5.1	4.2	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NNW100	A	4/27/99	14:41	MCS	40.37532	-73.8433	ST_I	2	>4	>4	7.32	7.58	0.26	7.45	1	43.864	1.34	4.23	3.15	6	PHYSICAL	NO	S/DM; ORG FLOC; WORMS @ Z; RPD=S LAYER
NNW100	B	4/27/99	14:42	MCS	40.37531	-73.8433	ST_I	2	>4	4 to 3	6.55	7.63	1.08	7.09	1	58.055	2.22	6.08	4.21	7	PHYSICAL	NO	S/HIST DM; RPD=S; ORG FLOC; WIPER SMEAR/CLASTS
NNW200	A	4/27/99	14:46	MCS	40.37617	-73.8437	INDET	2	4	3 to 2	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	INDET	NO	NO PEN; HARD SAND BOT
NNW200	E	4/28/99	15:33	MCS	40.37616	-73.8437	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	PHYSICAL	NO	NO PEN; HARD BOT; BRICK FRAGS; PEBBLES
NNW300	B	4/27/99	14:53	MCS	40.37700	-73.8441	ST_I	2	4	3 to 2	0.41	0.77	0.36	0.59	1	6.13	0.31	0.93	0.61	2	PHYSICAL	NO	AMBIENT S>P; RIPPLED; RPD>P; LOW PEN; SHELL PIECES
NNW300	C	4/27/99	14:54	MCS	40.37698	-73.8441	ST_I	2	4	3 to 2	3.3	5.26	1.96	4.28	1	64.202	3.14	5.46	4.55	7	PHYSICAL	NO	AMBIENT S>P; RIPPLED; RPD>P
NW0	A	4/27/99	14:12	MCS	40.37308	-73.8430	ST_I	2	4	3 to 2	3.92	6.7	2.78	5.31	1	66.976	2.99	6.6	4.77	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NW0	C	4/27/99	14:16	MCS	40.37296	-73.8431	ST_I	2	4	3 to 2	2.42	6.24	3.81	4.33	1	58.832	2.11	6.13	4.19	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
NW100	A	4/27/99	14:06	MCS	40.37372	-73.8439	ST_I	3	4	4 to 3	4.18	5.67	1.49	4.92	1	66.057	3.97	5.52	4.71	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SM SHELL PIECES
NW100	B	4/27/99	14:07	MCS	40.37374	-73.8439	ST_I	3	4	4 to 3	1.91	3.2	1.29	2.55	1	31.686	1.75	2.78	2.24	4	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
NW200	A	4/27/99	14:00	MCS	40.37440	-73.8446	ST_I	2	4	3 to 2	3.97	4.54	0.57	4.25	1	58.991	3.51	4.69	4.24	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
NW200	B	4/27/99	14:01	MCS	40.37441	-73.8445	ST_I	2	4	3 to 2	2.37	5.26	2.89	3.81	1	54.659	1.34	5.52	3.89	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
NW300	A	4/27/99	13:54	MCS	40.37512	-73.8453	ST_I_ON_III	2	>4	>4	14.48	14.95	0.46	14.72	1	28.406	1.34	3.45	2.04	8	BIOGENIC	NO	HIST DM>P; VOID; WORMS @ Z; NUCULA
NW300	B	4/27/99	13:55	MCS	40.37510	-73.8452	ST_I_TO_II	2	>4	>4	10.46	10.82	0.36	10.64	1	23.528	0.75	2.83	1.75	5	BIOGENIC	NO	HIST DM>P; WORMS @ Z; NUCULA
NW400	A	4/27/99	13:49	MCS	40.37582	-73.8461	ST_I_ON_III	-1	>4	>4	7.11	9.48	2.37	8.3	1	22.531	0.46	3.04	1.64	8	PHYSICAL	NO	HIST DM>P; VOIDS; BURROWS; ORG FLOC ON ROCKS; BRICKS; ROCKS
NW400	B	4/27/99	13:49	MCS	40.37582	-73.8460	ST_I	-1	>4	>4	3.25	7.94	4.69	5.59	1	6.205	0.21	1.87	1.31	3	PHYSICAL	NO	ROCKS+BRICKS+HIST DM>P; ORG FLOC ON ROCKS; WIPER CLASTS/SMEARS
NW500	A	4/27/99	13:44	MCS	40.37653	-73.8468	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	INDET	NO	NO PEN; HARD BOT; ROCKS
NW500	B	4/27/99	13:45	MCS	40.37652	-73.8467	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	INDET	NO	NO PEN; HARD BOT; ROCKS
S0	A	4/28/99	10:10	MCS	40.36877	-73.8411	ST_I	2	4	3 to 2	4.55	6.77	2.22	5.66	1	77.92	4.29	6.83	5.55	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
S0	C	4/28/99	10:12	MCS	40.36884	-73.8409	INDET	2	4	3 to 2	4.39	4.66	0.26	4.52	1	61.835	4.07	4.6	4.39	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
S100	A	4/28/99	10:18	MCS	40.36795	-73.8410	ST_I	2	4	3 to 2	3.17	4.29	1.11	3.73	1	51.675	2.75	4.29	3.64	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
S100	B	4/28/99	10:18	MCS	40.36795	-73.8410	ST_I	2	4	3 to 2	4.13	4.29	0.16	4.21	1	60.112	4.02	4.5	4.25	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
S200	A	4/28/99	10:26	MCS	40.36707	-73.8410	ST_I	2	4	3 to 2	2.22	3.86	1.64	3.04	1	38.907	2.06	3.65	2.73	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; TUBES?
S200	C	4/28/99	10:29	MCS	40.36699	-73.8409	ST_I	2	4	3 to 2	2.49	3.76	1.27	3.12	1	48.889	2.22	3.97	3.47	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; SHELL HASH
S300	B	4/28/99	10:33	MCS	40.36606	-73.8410	ST_I	2	4	3 to 2	1.38	3.65	2.28	2.51	1	29.904	1.27	3.81	2.13	4	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
S300	C	4/28/99	10:34	MCS	40.36605	-73.8411	INDET	2	4	3 to 2	1.96	4.13	2.17	3.04	1	36.248	1.53	4.18	2.54	99	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
S400	A	4/28/99	10:40	MCS	40.36526	-73.8410	ST_I	3	>4	4 to 3	7.04	7.41	0.37	7.22	1	38.757	1.75	4.18	2.79	5	BIOGENIC	NO	S/HIST DM; RPD=LIGHT S LAYER; TUBES; NUCULA
S400	C	4/28/99	10:43	MCS	40.36523	-73.8410	ST_I	3	>4	4 to 3	9.31	9.79	0.48	9.55	1	62.318	3.7	6.19	4.49	7	BIOGENIC	NO	S/HIST DM; RPD=LIGHT S LAYER; BURROWING ANENOME; NUCULA
S500	A	4/28/99	10:48	MCS	40.36428	-73.8409	ST_I_ON_III	2	>4	>4	12.17	12.8	0.63	12.49	1	27.37	1.11	2.49	1.95	8	BIOGENIC	NO	HIST DM>P; TUBES; VOID; NUCULA
S500	B	4/28/99	10:49	MCS	40.36428	-73.8410	ST_I	2	>4	>4	9.74	11.64	1.9	10.69	1	8.997	0.37	0.75	0.6	2	BIOGENIC	NO	HIST DM>P; TUBES; NUCULA; WIPER CLASTS/SMEARS
S600	A	4/28/99	10:55	MCS	40.36341	-73.8411	ST_I	2	>4	>4	9.95	10.9	0.95	10.42	1	23.613	0.85	2.33	1.78	4	BIOGENIC	NO	HIST DM>P; 2 ANENOMES; TUBES; NUCULA
S600	B	4/28/99	10:56	MCS	40.36340	-73.8411	ST_I	2	>4	>4	10.9	11.06	0.16	10.98	1	12.974	0.05	2.33	1.16	3	BIOGENIC	NO	HIST DM>P; TUBES; NUCULA; WIPER SMEAR/CLAST
SE0	A	4/28/99	12:26	MCS	40.36906	-73.8388	ST_I	2	4	3 to 2	0.16	2.96	2.8	1.56	NA	NA	NA	NA	NA	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD=P
SE0	B	4/28/99	12:28	MCS	40.36898	-73.8388	ST_I	2	4	3 to 2	1.72	2.26	0.54	1.99	1	28.585	1.45	2.37	2.01	4	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SE100	A	4/28/99	12:22	MCS	40.36833	-73.8380	ST_I	2	4	3 to 2	0.32	2.04	1.72	1.18	NA	NA	NA	NA	NA	99	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SE100	C	4/28/99	12:23	MCS	40.36836	-73.8380	ST_I	2	4	3 to 2	0.97	3.6	2.63	2.29	1	33.388	0.16	3.76	2.37	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SE200	A	4/28/99	12:15	MCS	40.36761	-73.8374	INDET	2	4	3 to 2	0.54	2.47	1.94	1.51	1	25.716	0.43	2.53	1.83	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
SE200	B	4/28/99	12:18	MCS	40.36762	-73.8374	ST_I	2	4	3 to 2	0.11	1.18	1.08	0.65	NA	NA	NA	NA	NA	99	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SE300	A	4/28/99	12:07	MCS	40.36695	-73.8366	ST_I	2	4	3 to 2	2.38	3.18	0.79	2.78	1	36.887	2.22	3.17	2.59	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SE300	C	4/28/99	12:09	MCS	40.36693	-73.8366	ST_I	2	4	3 to 2	1.8	2.8	1.01	2.3	1	30.911	1.8	2.7	2.17	4	PHYSICAL	NO	CAP S>P; ORG FLOC; RPD>P
SE400	A	4/28/99	12:03	MCS	40.36625	-73.8359	ST_I	2	4	4 to 3	1.69	2.59	0.9	2.14	1	15.788	0.11	2.03	1.28	3	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; TUBES
SE400	C	4/28/99	12:04	MCS	40.36619	-73.8359	ST_I	2	>4	4 to 3	4.97	5.98	1.01	5.48	1	59.483	3.23	5.03	4.22	7	PHYSICAL	NO	CAP S/HIST DM; RIPPLED; ORG FLOC; TUBES; RPD=S LAYER
SE500	A	4/28/99	11:55	MCS	40.36552	-73.8351	ST_I	2	4	3 to 2	0.48	1.85	1.38	1.16	NA	NA	NA	NA	NA	99	PHYSICAL	NO	AMBIENT S>P; HARD BOT LOW PEN; RIPPLED; LG SHELL PIECE; PEBBLES
SE500	C	4/28/99	11:56	MCS	40.36552	-73.8351	INDET	2	4	3 to 2	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	PHYSICAL	NO	NO PEN; HARD SANDY BOT; AMBIENT SAND; TUBES; ALGAE
SE600	E	4/29/99	11:31	MCS	40.36478	-73.8344	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	INDET	NO	NO PEN; HARD BOT; SM ROCKS; BRICK FRAGS
SE600	F	4/29/99	11:32	MCS	40.36479	-73.8344	ST_I	3	4	4 to 3	0.97	2.42	1.45	1.69	1	23.074	0.75	2.63	1.61	4	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; WORM TUBES
SE700	A	4/28/99	11:41	MCS	40.36407	-73.8337	ST_I	1	4	3 to 2	1.16	5.4	4.23	3.28	1	45.828	0.26	5.5	3.16	6	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
SE700	B	4/28/99	11:42	MCS	40.36406	-73.8337	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	INDET	NO	NO PEN; HARD BOT; LG ALGAE COVERED ROCK
SSE0	A	4/28/99	11:31	MCS	40.36679	-73.8389	ST_I	2	4	3 to 2	2.12	3.7	1.59	2.91	1	41.424	2.06	3.7	2.93	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SSE0	C	4/28/99	11:32	MCS	40.36679	-73.8389	ST_I	2	4	3 to 2	4.13	4.87	0.74	4.5	1	61.755	3.07	4.71	4.4	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SSE100	B	4/28/99	11:25	MCS	40.36600	-73.8385	ST_I	2	>4	3 to 2	3.7	4.5	0.79	4.1	1	34.668	1.64	3.39	2.46	5	PHYSICAL	NO	CAP S/HIST DM; RIPPLED; RPD=S LAYER; TUBES
SSE100	E	4/29/99	11:22	MCS	40.36588	-73.8384	ST_I	3	4	4 to 3	3.98	5.05	1.08	4.52	1	67.155	3.98	5.16	4.77	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SSE200	A	4/28/99	11:19	MCS	40.36506	-73.8380	ST_I_ON_III	2	>4	>4	9.1	10.05	0.95	9.58	1	23.089	0.79	2.43	1.62	8	PHYSICAL	NO	CAP S/HIST DM; RIPPLED; RPD=S LAYER; TUBES; VOIDS
SSE200	B	4/28/99	11:25	MCS	40.36505	-73.8380	ST_I	2	>4	4 to 3	3.7	4.5	0.79	4.1	1	34.668	1.64	3.39	2.46	9	PHYSICAL	NO	S/HIST DM; RIPPLED; RPD=S LAYER; TUBES

STAT	REPL	DATE	TIME	AYST	LAT	LONG	SS	GSMX	GSMN	GSMM	PNMN	PNMX	PNRNG	PENMEAN	RPDCNT	RPDAREA	RPDMN	RPDMX	RPDMEAN	OSI	SURF	LODO	FULL CMNT
SSE200	F	4/29/99	11:15	MCS	40.36509	-73.8381	INDET	-1	-1	<-1	0.05	0.05	0	0.05	NA	NA	NA	NA	NA	99	BIOGENIC	NO	NO PEN; HARD BOT; LG ROCK; ALGAE ON ROCK
SSE300	A	4/28/99	11:03	MCS	40.36421	-73.8375	ST_I	3	4	4 to 3	1.75	3.97	2.22	2.86	1	21.261	0.64	2.89	1.59	4	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC
SSE300	C	4/28/99	11:04	MCS	40.36421	-73.8375	ST_I	2	4	4 to 3	0.69	1.43	0.74	1.06	1	16.693	0.74	1.59	1.14	3	BIOGENIC	NO	S>P; LOW PEN; HARD BOT; ORG FLOC; RPD>P
SSW0	A	4/28/99	9:30	MCS	40.36760	-73.8424	ST_I	3	4	4 to 3	0.05	2.5	2.45	1.28	1	13.506	0.05	2.5	1.1	3	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; UNDERPEN
SSW0	B	4/28/99	9:30	MCS	40.36764	-73.8425	ST_I	3	4	4 to 3	0.05	0.26	0.21	0.16	NA	NA	NA	NA	NA	99	PHYSICAL	NO	CAP S>P; V LOW PEN; HARD S BOT; RIPPLED
SSW100	A	4/28/99	9:45	MCS	40.36677	-73.8430	ST_I	2	4	3 to 2	3.18	5.63	2.45	4.4	1	51.726	2.86	5.78	3.69	6	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SSW100	B	4/28/99	9:45	MCS	40.36683	-73.8430	ST_I	3	4	3 to 2	3.18	6.2	3.02	4.69	1	70.847	3.02	6.25	5.06	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
SSW200	A	4/28/99	9:52	MCS	40.36591	-73.8435	ST_I	2	4	3 to 2	8.18	8.7	0.52	8.44	1	48.765	1.86	4.89	3.7	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; TUBES
SSW200	C	4/28/99	9:52	MCS	40.36591	-73.8435	ST_I	3	4	3 to 2	2.17	3.49	1.32	2.83	1	42.371	2.01	3.6	2.98	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; SHRIMP & HERMIT CRAB IN FARFIELD; SHELL PIECEPHYSICAL
SSW300	C	4/28/99	9:59	MCS	40.36514	-73.8439	ST_I	3	4	3 to 2	2.38	3.97	1.59	3.17	1	40.229	2.28	3.92	2.83	5	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SSW300	D	4/29/99	10:56	MCS	40.36501	-73.8439	ST_I	2	4	4 to 3	4.03	6.24	2.2	5.13	1	74.571	3.66	5.97	5.32	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
SW0	B	4/28/99	8:47	MCS	40.36899	-73.8432	INDET	2	4	3 to 2	4.69	5.92	1.22	5.31	1	79.317	4.8	5.92	5.67	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
SW0	C	4/28/99	8:50	MCS	40.36896	-73.8432	ST_I	2	4	3 to 2	3.01	5.92	2.91	4.46	1	59.464	2.55	5.61	4.26	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SW100	A	4/28/99	8:54	MCS	40.36825	-73.8438	ST_I	3	4	4 to 3	2.55	5.1	2.55	3.83	1	52.437	2.35	5.1	3.76	7	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P
SW100	C	4/28/99	8:56	MCS	40.36824	-73.8439	ST_I	3	4	4 to 3	1.46	3.85	2.4	2.66	1	37.955	1.15	3.49	2.7	5	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
SW200	A	4/28/99	9:01	MCS	40.36759	-73.8446	ST_I	3	4	4 to 3	1.82	2.08	0.26	1.95	1	25.902	1.56	2.19	1.82	4	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC
SW200	C	4/28/99	9:07	MCS	40.36753	-73.8447	ST_I	2	4	3 to 2	0.78	1.61	0.83	1.2	1	14.377	0.62	1.41	0.98	3	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; SM SHELL PIECES; UNDERPEN
SW300	B	4/28/99	9:11	MCS	40.36681	-73.8453	ST_I	3	4	3 to 2	1.82	2.08	0.26	1.95	1	24.601	0.99	2.08	1.7	4	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; UNDERPEN
SW300	C	4/28/99	9:12	MCS	40.36682	-73.8453	ST_I	3	4	4 to 3	0.94	1.82	0.89	1.38	1	18.972	0.94	1.82	1.32	3	PHYSICAL	NO	CAP S>P; RIPPLED; ORG FLOC; RPD>P; UNDERPEN
SW400	B	4/28/99	9:16	MCS	40.36614	-73.8461	ST_I	3	>4	4 to 3	2.92	3.85	0.94	3.39	1	32.621	0.78	3.75	2.34	5	PHYSICAL	NO	CAP S/HIST DM; RIPPLED; ORG FLOC; RDS=S LAYER; TUBES; SULFIDIC @ Z
SW400	C	4/28/99	9:17	MCS	40.36614	-73.8461	ST_I	3	>4	4 to 3	6.82	7.14	0.31	6.98	1	51.038	2.76	4.9	3.65	6	PHYSICAL	NO	CAP S/HIST DM; RPD=S LAYER; WIPER CLAST/SMEARS; SULFIDIC @ Z; BURROW?
SW500	A	4/28/99	9:20	MCS	40.36546	-73.8468	ST_I	3	4	4 to 3	1.51	2.08	0.57	1.8	1	23.707	0.73	2.03	1.68	4	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; TUBES; WIPER CLASTS; RPD>P; UNDERPEN
SW500	C	4/28/99	9:23	MCS	40.36548	-73.8468	ST_I	3	4	4 to 3	0.42	2.71	2.29	1.56	1	23.948	0.16	2.86	1.75	4	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; UNDERPEN
W0	A	4/27/99	12:05	MCS	40.37095	-73.8419	ST_I	3	4	4 to 3	2.97	4.15	1.18	3.56	1	48.665	2.62	4.15	3.5	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W0	B	4/27/99	12:06	MCS	40.37096	-73.8419	ST_I	2	4	4 to 3	3.03	6.1	3.08	4.56	1	58.22	2.72	5.74	4.16	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
W100	B	4/27/99	12:11	MCS	40.37103	-73.8431	ST_I	3	4	3 to 2	3.18	5.13	1.95	4.15	1	62.383	2.41	5.18	4.49	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SM PIECE SHELL
W100	C	4/27/99	12:12	MCS	40.37102	-73.8431	ST_I	2	4	3 to 2	2.26	4.82	2.56	3.54	1	48.57	2.1	4.82	3.48	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W200	A	4/27/99	12:18	MCS	40.37102	-73.8442	ST_I	3	4	3 to 2	4.87	5.38	0.51	5.13	1	72.483	4.72	5.44	5.24	7	PHYSICAL	NO	CAP S>P; RIPPLES; RPD>P
W200	B	4/27/99	12:18	MCS	40.37103	-73.8443	ST_I	3	4	3 to 2	3.38	5.85	2.46	4.62	1	58.634	3.33	5.79	4.25	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W300	A	4/27/99	12:23	MCS	40.37101	-73.8454	ST_I	2	4	4 to 3	1.64	5.69	4.05	3.67	1	50.918	1.64	5.64	3.65	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W300	B	4/27/99	12:24	MCS	40.37100	-73.8454	ST_I	3	4	4 to 3	2.92	3.74	0.82	3.33	1	45.904	2.87	3.74	3.28	6	PHYSICAL	NO	CAP S>P; RIPLLED; RPD>P; ORG FLOC
W400	A	4/27/99	12:31	MCS	40.37094	-73.8466	ST_I	3	4	4 to 3	4.41	5.28	0.87	4.85	1	66.015	4.21	5.33	4.74	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W400	B	4/27/99	12:32	MCS	40.37094	-73.8466	INDET	3	4	4 to 3	2.41	4.1	1.69	3.26	1	38.461	2.1	4.05	2.74	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W500	A	4/27/99	12:38	MCS	40.37096	-73.8477	ST_I	3	4	3 to 2	5.49	6.51	1.03	6	1	82.72	4.31	6.36	5.89	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; SNAIL IN FARFIELD?
W500	C	4/27/99	12:39	MCS	40.37101	-73.8478	ST_I	2	4	3 to 2	3.54	3.9	0.36	3.72	1	49.496	3.23	3.9	3.58	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
W600	A	4/27/99	12:44	MCS	40.37104	-73.8489	ST_I	2	4	4 to 3	1.76	3.16	1.39	2.46	1	30.983	1.71	3.64	2.19	4	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; SM SNAIL
W600	B	4/27/99	12:44	MCS	40.37103	-73.8489	ST_I	3	4	4 to 3	4.51	5.64	1.13	5.08	1	68.513	4.21	5.49	4.93	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
W700	A	4/27/99	13:02	MCS	40.37101	-73.8502	ST_I	3	4	3 to 2	2.41	3.59	1.18	3	1	42.453	2.36	3.49	3.07	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SM SNAIL IN FARFIELD
W700	B	4/27/99	13:02	MCS	40.37101	-73.8502	INDET	3	4	3 to 2	4.62	5.33	0.72	4.98	1	70.066	4.36	5.49	5.05	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
WNW0	A	4/27/99	13:29	MCS	40.37270	-73.8453	ST_I	2	4	3 to 2	2.78	5.36	2.58	4.07	1	61.515	2.73	5.46	4.33	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WNW0	B	4/27/99	13:29	MCS	40.37272	-73.8453	INDET	2	4	3 to 2	2.53	5.62	3.09	4.07	1	61.164	2.37	5.57	4.37	99	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
WNW100	A	4/27/99	13:22	MCS	40.37308	-73.8464	ST_I	2	4	3 to 2	3.51	7.53	4.02	5.52	1	75.524	3.09	7.32	5.4	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
WNW100	B	4/27/99	13:25	MCS	40.37303	-73.8464	ST_I	2	4	3 to 2	3.66	4.07	0.41	3.87	1	51.567	2.06	4.07	3.61	6	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WNW200	B	4/27/99	13:18	MCS	40.37341	-73.8475	ST_I	3	4	4 to 3	2.31	3.74	1.44	3.03	1	37.732	2.21	3.85	2.73	5	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WNW200	C	4/27/99	13:18	MCS	40.37342	-73.8474	ST_I	3	4	4 to 3	2.1	5.8	3.69	3.95	1	55.439	2.1	5.74	3.98	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WNW300	A	4/27/99	13:10	MCS	40.37374	-73.8485	ST_I	2	>4	>4	11.13	12.92	1.79	12.03	1	42.854	1.23	4.51	3.09	6	PHYSICAL	NO	S/HIST DM; RIPPLED; RPD>S
WNW300	B	4/27/99	13:10	MCS	40.37375	-73.8485	ST_I	3	>4	>4	11.95	12.87	0.92	12.41	1	20.022	0.56	3.03	1.39	3	PHYSICAL	NO	S/HIST DM; RPD>S; WIPER CLASTS/SMEARS
WSW0	A	4/28/99	8:03	MCS	40.36966	-73.8453	ST_I	3	4	4 to 3	2.58	3.66	1.08	3.12	1	40.756	2.47	3.71	2.91	5	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WSW0	B	4/28/99	8:04	MCS	40.36969	-73.8454	ST_I	3	4	4 to 3	2.06	3.71	1.65	2.89	1	32.642	1.49	3.25	2.31	5	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC; SNAIL IN FARFIELD
WSW100	A	4/28/99	8:17	MCS	40.36927	-73.8464	ST_I	2	4	3 to 2	4.28	6.49	2.22	5.39	1	74.423	3.92	6.34	5.3	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P; ORG FLOC
WSW100	B	4/28/99	8:17	MCS	40.36925	-73.8464	ST_I	3	4	3 to 2	4.18	5.98	1.8	5.08	1	71.805	3.71	6.08	5.12	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
WSW200	B	4/28/99	8:22	MCS	40.36894	-73.8475	ST_I	2	>4	3 to 2	10.98	11.49	0.52	11.24	1	101.356	3.92	9.79	7.33	7	PHYSICAL	NO	CAP S/HIST DM; RPD>S
WSW200	C	4/28/99	8:26	MCS	40.36897	-73.8476	ST_I	2	>4	3 to 2	12.84	13.14	0.31	12.99	1	57.223	3.51	5.21	4.11	7	PHYSICAL	NO	CAP S/HIST DM; RIPPLED; RPD>S; ARTIFACT=SMEAR
WSW300	A	4/28/99	8:31	MCS	40.36871	-73.8486	ST_I	2	4	4 to 3	2.91	4.9	1.99	3.9	1	52.636	2.7	4.85	3.81	7	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
WSW300	B	4/28/99	8:37	MCS	40.36859	-73.8486	ST_I	2	4	4 to 3	2.09	4.08	1.99	3.09	1	41.046	2.04	4.08	2.93	5	PHYSICAL	NO	CAP S>P; RIPPLED; RPD>P
NREF01	A	4/29/99	10:19	MCS	40.36541	-73.8768	INDET	1	3	3 to 2	5.81	11.24	5.43	8.52	1	70.556	1.12	7.7	5.58	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC
NREF01	C	4/29/99	10:25	MCS	40.36544	-73.8767	ST_I	0	4	3 to 2	10.38	13.71	3.33	12.04	1	109.561	4.87	10.59	8.46	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC
NREF02	A	4/29/99	10:32	MCS	40.36553	-73.8750	INDET	0	3	2 to 1	4.52	7.53	3.01	6.02	1	83.911	2.9	8.23	5.92	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF02	B	4/29/99	10:33	MCS	40.36543	-73.8750	ST_I	2	4	3 to 2	2.04	3.12	1.07	2.58	1	33.926	1.77	3.12	2.37	5	PHYSICAL	NO	S>P; ORG FLOC; RPD>P

STAT	REPL	DATE	TIME	AYST	LAT	LONG	SS	GSMX	GSMN	GSMM	PNMN	PNMX	PNRNG	PENMEAN	RPDCNT	RPDAREA	RPDMN	RPDMX	RPDMEAN	OSI	SURF	LODO	FULL CMNT
NREF05	A	4/29/99	10:06	MCS	40.36494	-73.8756	INDET	2	4	3 to 2	2.63	3.23	0.59	2.93	1	42.251	2.47	3.28	2.98	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF05	B	4/29/99	10:08	MCS	40.36499	-73.8755	INDET	2	4	3 to 2	2.42	2.9	0.48	2.66	1	36.246	2.15	2.9	2.55	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF06	A	4/29/99	9:53	MCS	40.36500	-73.8726	ST_I	1	3	2 to 1	5.43	7.8	2.37	6.61	1	96.238	2.04	7.58	6.74	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF06	B	4/29/99	9:53	MCS	40.36493	-73.8727	INDET	1	3	3 to 2	1.45	5.22	3.76	3.33	1	45.517	1.45	5.16	3.19	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF07	A	4/29/99	9:35	MCS	40.36407	-73.8738	ST_I	2	3	3 to 2	3.71	4.52	0.81	4.11	1	53.861	2.37	4.3	3.81	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF07	B	4/29/99	9:36	MCS	40.36408	-73.8738	ST_I	2	3	3 to 2	2.15	6.94	4.78	4.54	1	60.328	1.88	6.34	4.24	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF08	A	4/29/99	9:41	MCS	40.36407	-73.8733	ST_I	2	3	3 to 2	2.96	4.62	1.67	3.79	1	56.546	1.08	4.62	4	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF08	B	4/29/99	9:47	MCS	40.36411	-73.8733	ST_I	2	3	3 to 2	1.88	3.01	1.13	2.45	1	33.096	1.83	2.85	2.31	5	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF12	A	4/29/99	9:27	MCS	40.36278	-73.8751	ST_I	2	3	3 to 2	4.41	5.48	1.08	4.95	1	68.815	4.41	5.86	4.84	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF12	C	4/29/99	9:30	MCS	40.36280	-73.8751	ST_I	1	3	3 to 2	2.69	2.96	0.27	2.82	1	39.162	2.26	2.96	2.75	5	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF14	A	4/29/99	9:21	MCS	40.36230	-73.8767	ST_I	2	3	3 to 2	1.4	4.57	3.17	2.98	1	35.052	1.18	4.3	2.48	5	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF14	B	4/29/99	9:21	MCS	40.36231	-73.8767	INDET	2	3	3 to 2	4.95	6.61	1.67	5.78	1	86.837	1.88	6.94	6.07	99	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF16	A	4/29/99	9:09	MCS	40.36225	-73.8738	ST_I	0	3	2 to 1	4.25	8.6	4.35	6.42	1	94.21	3.87	8.76	6.59	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF16	B	4/29/99	9:10	MCS	40.36222	-73.8739	INDET	2	3	3 to 2	5.97	6.88	0.91	6.42	1	91.579	5.75	6.83	6.46	99	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
NREF18	A	4/29/99	8:58	MCS	40.36184	-73.8726	ST_I	1	3	3 to 2	3.17	5.86	2.69	4.52	1	65.293	2.8	5.7	4.61	7	PHYSICAL	NO	S>P; RIPPLED; RPD>P
NREF18	B	4/29/99	9:01	MCS	40.36193	-73.8727	ST_I	2	3	3 to 2	3.44	4.03	0.59	3.74	1	53.449	3.23	4.3	3.78	7	PHYSICAL	NO	S>P; ORG FLOC; RPD>P
SREF04	A	4/28/99	15:09	MCS	40.33728	-73.8670	INDET	2	4	3 to 2	2.47	3.76	1.29	3.12	1	44.207	2.26	3.76	3.13	99	PHYSICAL	NO	S>P; RIPPLED; RPD>P
SREF04	B	4/28/99	15:12	MCS	40.33723	-73.8671	ST_I	2	4	3 to 2	5.86	6.4	0.54	6.13	1	84.719	5.65	6.4	6.04	7	PHYSICAL	NO	S>P; ORG FLOC; RPD>P
SREF07	A	4/28/99	15:01	MCS	40.33581	-73.8705	ST_I	2	4	3 to 2	2.8	4.78	1.99	3.79	1	48.494	2.69	4.41	3.44	6	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SREF07	C	4/28/99	15:02	MCS	40.33583	-73.8706	ST_I	2	4	3 to 2	3.06	4.35	1.29	3.71	1	54.467	2.96	4.52	3.85	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SREF09	A	4/28/99	14:54	MCS	40.33579	-73.8694	ST_I	1	4	3 to 2	2.74	3.71	0.97	3.23	1	44.637	2.15	3.87	3.15	6	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SREF09	B	4/28/99	14:55	MCS	40.33579	-73.8694	ST_I	1	4	3 to 2	3.28	5.27	1.99	4.27	1	53.89	3.06	5.16	3.86	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SREF10	A	4/28/99	14:45	MCS	40.33584	-73.8676	ST_I	2	4	3 to 2	2.42	4.25	1.83	3.33	1	41.515	2.2	4.3	2.94	5	PHYSICAL	NO	S>P; RIPPLED; RPD>P
SREF10	C	4/28/99	14:45	MCS	40.33585	-73.8676	ST_I	2	4	3 to 2	2.96	4.46	1.51	3.71	1	55.633	2.8	4.52	4.01	7	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P
SREF13	B	4/28/99	14:28	MCS	40.33453	-73.8687	ST_I	2	4	4 to 3	1.61	1.83	0.22	1.72	1	23.735	1.29	1.99	1.66	4	PHYSICAL	NO	S>P; RIPPLED; RPD>P
SREF13	C	4/28/99	14:29	MCS	40.33453	-73.8687	ST_I	3	4	4 to 3	0.11	0.43	0.32	0.27	NA	NA	NA	NA	NA	99	PHYSICAL	NO	S>P; RIPPLED; SHELL IN FARFIELD
SREF14	A	4/28/99	14:21	MCS	40.33402	-73.8711	ST_I	2	4	3 to 2	0.81	1.72	0.91	1.26	1	18.571	0.59	1.56	1.3	3	PHYSICAL	NO	S>P; RIPPLED; ORG FLOC; RPD>P; TUBES
SREF14	C	4/28/99	14:23	MCS	40.33403	-73.8712	ST_I	3	4	4 to 3	0.22	1.56	1.34	0.89	1	12.721	0.11	1.51	0.87	3	PHYSICAL	NO	S>P; RIPPLED; TUBES; RPD>P
SREF15	A	4/28/99	14:16	MCS	40.33402	-73.8707	ST_I	2	4	3 to 2	1.88	3.33	1.45	2.61	1	33.955	1.72	3.39	2.43	5	PHYSICAL	NO	AMB S>P; RIPPLED; TUBES; RPD>P
SREF15	B	4/28/99	14:16	MCS	40.33403	-73.8707	ST_I	2	4	4 to 3	1.61	3.33	1.72	2.47	1	31.241	1.02	3.39	2.21	4	PHYSICAL	NO	S>P; RIPPLED; TUBES; RPD>P
SREF16	A	4/28/99	14:09	MCS	40.33405	-73.8694	ST_I	2	4	3 to 2	1.56	1.88	0.32	1.72	1	21.891	1.34	1.83	1.54	4	PHYSICAL	NO	S>P; ORG FLOC; RPD>P
SREF16	B	4/28/99	14:10	MCS	40.33405	-73.8694	ST_I	2	4	3 to 2	2.63	3.66	1.02	3.15	1	45.037	2.53	3.76	3.2	6	PHYSICAL	NO	AMB S>P; RIPPLED; ORG FLOC; RPD>P
SREF17	B	4/28/99	14:01	MCS	40.33397	-73.8688	ST_I	2	>4	4 to 3	2.85	4.14	1.29	3.49	1	20.599	0.16	2.2	1.61	4	PHYSICAL	NO	THIN S/HIST DM; TUBES
SREF17	C	4/28/99	14:02	MCS	40.33398	-73.8688	ST_I	3	>4	>4	6.56	7.53	0.97	7.04	1	7.298	0.21	0.7	0.46	2	BIOGENIC	NO	HIST DM>P; TUBES; WORM @ Z; REDUCED SEDIMENT
SREF20	A	4/28/99	13:53	MCS	40.33361	-73.8671	ST_I	2	4	3 to 2	1.99	2.74	0.75	2.37	1	32.54	1.83	3.12	2.3	5	PHYSICAL	NO	AMB S>P; RIPPLED; ORG FLOC; RPD=P; SHELL PIECES
SREF20	B	4/28/99	13:54	MCS	40.33362	-73.8671	ST_I	2	4	3 to 2	1.88	3.76	1.88	2.82	1	41.143	1.61	3.71	3	5	PHYSICAL	NO	AMB S>P; RIPPLED; RPD>P